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Publications of the Exobiology Program for 1989

A Special Bibliography

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INTRODUCTION

The Exobiology Program, within the Office of Space Science and Applications of the National Aeronautics and Space Administration, is an integrated program designed to investigate those processes that may have been responsible for or related to the origin, evolution, and distribution of life in the universe.

This report contains a listing of 1989 publications resulting from research supported by the Exobiology Program. Our intent in compiling this report is twofold: We want to provide the scientific community with an annual publication listing (as we have done since 1975) of current NASA-supported research in this field, and we hope to stimulate the exchange of information and ideas among scientists working in the different areas of the program.

Research supported by the Exobiology Program is explored in the areas of Cosmic Evolution of Biogenic Compounds, Prebiotic Evolution, Early Evolution of Life, and Evolution of Advanced Life. Pre-mission and pre-project activities supporting these areas are supported in the areas of Solar System Exploration and Search for Extraterrestrial Intelligence. The Planetary Protection subject area is included here because of its direct relevance to the Exobiology Program.

EACH AREA IS DEFINED AS FOLLOWS:

COSMIC EVOLUTION OF BIOGENIC COMPOUNDS focuses on the history of the biogenic elements (C,H,N,O,P,S) and their compounds in the galaxy and the early solar system. This includes: (1) tracing the physical and chemical pathways taken by the biogenic elements and their compounds from their origins in stars to their incorporation in the pre-planetary bodies; (2) determining the kinds of measurements that can be made on the biogenic elements and compounds in the galaxy and solar system and prebiotic evolution and origin of life; and (3) determining the ways in which the physical and chemical properties of the biogenic elements and compounds may have influenced the course of events during the formation of the solar system and the component bodies.

PREBIOTIC EVOLUTION involves research and analysis in two major areas: (1) the consequences of planetary evolution on the physical environment of the Earth and planets, and (2) the evolution of molecules and molecular systems under the constraints imposed by the physical environment and the appearance, a posteriori, of living systems on Earth. It also assesses the importance of the physical-chemical processes associated with the dynamic development of planetary surfaces.

EARLY EVOLUTION OF LIFE focuses on the nature of the most primitive organisms, determining the environment in which they evolved, and the way in which they influenced that environment. Investigations are executed through the use of the molecular record in living organisms and the geological record in rocks. These records are used to determine when and in what setting life first appeared; to determine the characteristics of the first successful living organisms; to understand the phylogeny and physiology of microorganisms that inhabit hydrothermal areas now thought to be analogs of primitive environments; to determine the original nature of biotic energy transduction, membrane function, and information processing through study of extant microbes; and to elucidate the physical, chemical, and biotic forces operating on microbial evolution.

EVOLUTION OF ADVANCED LIFE examines the influence of astrophysical, stellar and solar system events on the evolution of advanced life on Earth. Research in this area attempts to understand possible evolutionary pathways for advanced life and to develop a program plan for a paleontological data base.

SOLAR SYSTEM EXPLORATION focuses on providing specific information on the elemental and chemical composition, mainly with respect to gases and volatiles, of the atmospheres and surfaces of solar system bodies, including planets and their satellites, comets, asteroids, meteorites, and dust in space. Improved methods, instrumentation, and experiments will be developed for in situ chemical analyses of the volatile species associated with the bodies to be investigated.

SEARCH FOR EXTRATERRESTRIAL INTELLIGENCE (SETI) involves the search for extraterrestrial intelligent life by detecting signals in the electromagnetic spectrum. Principal emphasis has been on technology development for the microwave observing project.

PLANETARY PROTECTION focuses on environmental protection of planets of biological interest from potentially harmful contamination from terrestrial sources during future exploration, based on explicit guidelines established for each planet and for each type of mission. It also focuses on protection of the Earth from potential hazards posed by returned sample missions.

This bibliography is divided into the areas noted above. Within each research area, references are listed alphabetically by author. Authors who are Principal Investigators are identified by an asterisk. In addition, current addresses for all Principal Investigators are given in the Appendix.

We wish to thank all the participants in the Exobiology Program for their cooperation in responding to our request for a listing of their 1989 publications. We also wish to thank Janice Wallace-Robinson and F. Ronald Dutcher for their editorial and technical assistance and Audrey Brown and Stephen Szibler for their technical assistance.

John D. Rummel
Exobiology Program Manager
March, 1991

COSMIC EVOLUTION OF BIOGENIC COMPOUNDS

Allamandola*, L.; Bar-Nun, A.; Brock, T.; Chang*, S.; Davies, R.E.; Greenberg, J.M.; Hochstein*, L.; Horneck, G.; Huntress, W.; Miller*, S.; Neelson, K.; Usher*, D.
In situ investigations.

In: *Exobiology in Earth Orbit* (DeFrees, D., Brownlee, D., Tarter, J., Usher, D., Irvine, W., Klein, H., Eds.). Moffett Field, CA: NASA, Ames Research Center, p. 89-99, 1989. (NASA-SP-500) (GWU 11602)

Allamandola*, L.J.; Bregman, J.D.; Sandford, S.A.; Tielens, A.G.G.M.; Witteborn, F.C.; Wooden, D.H.; Rank, D.

The discovery of a new infrared emission feature at 1905 wavenumbers (5.25 microns) in the spectrum of BD + 30° 3639 and its relation to the polycyclic aromatic hydrocarbon model.

Astrophysical Journal (Letters) 345(2): L59-L62, 1989. (GWU 11658)

Allamandola*, L.J.; Tielens, A.G.G.M.

Interstellar Dust. Dordrecht, Holland: Kluwer, 525 p., 1989. (GWU 11761)

Allamandola*, L.J.; Tielens, A.G.G.M.; Barker, J.R.

Interstellar polycyclic aromatic hydrocarbons: The infrared emission bands, the excitation/emission mechanism, and the astrophysical implications.

Astrophysical Journal Supplement Series 71: 733-775, 1989. (GWU 11620)

Bar-Nun, A.; Heifetz, E.; Prialnik, D. (Owen, T. = P.I.)

Thermal evolution of Comet P/Tempel 1: Representing the group of targets for the *CRAF* and *CNSR* missions.

Icarus 79: 116-124, 1989. (GWU 11548)

Bar-Nun, A.; Kleinfeld, I. (Owen, T. = P.I.)

On the temperature and gas composition in the region of comet formation.

Icarus 80: 243-253, 1989. (GWU 11547)

Blake*, D.; Fleming, R.H.; Bunch*, T.E.

Identification and characterization of a carbonaceous, titanium containing interplanetary dust particle (Abstract).

Lunar and Planetary Science Conference XX: 84-85, 1989. (GWU 11396)

Blake*, D.F.

Analytical electron microscopy of biogenic and inorganic carbonates (Abstract).

In: *Exobiology and Future Mars Missions* (McKay, C.P., Davis, W.L., Eds.) Moffett Field, CA: NASA, Ames Research Center, p. 10, 1989. (NASA-CP-10027) (GWU 11943)

Bregman, J.D.; Allamandola*, L.J.; Tielens, A.G.G.M.; Geballe, T.R.; Witteborn, F.C.

The infrared emission bands. II. A spatial and spectral study of the Orion Bar.

Astrophysical Journal 344: 791-798, 1989. (GWU 11329)

Brooke, T.Y.; Knacke, R.F.; Owen*, T.C.; Tokunaga, A.T.

The 3.4 micron emission in comets.

In: *Interstellar Dust: Contributed Papers* (Tielens, A.G.G.M., Allamandola, L.J., Eds.).

Moffett Field, CA: NASA, Ames Research Center, p. 431, 1989. (NASA-CP-3036) (GWU 11545)

- Brownlee, D.; Bunch*, T.; Chang*, S.; Kerridge*, J.; Wolfe, J.
Cosmic dust collection.
In: *Exobiology in Earth Orbit* (DeFrees, D., Brownlee, D., Tarter, J., Usher, D., Irvine, W., Klein, H., Eds.). Moffett Field, CA: NASA, Ames Research Center, p. 77-87, 1989. (NASA-SP-500) (GWU 11599)
- Chang*, S.
Studies of samples returned from a comet nucleus by the Rosetta Mission (Abstract).
Origins of Life and Evolution of the Biosphere 19: 481, 1989. (GWU 11998)
- Cohen, M.; Bregman, J.; Witteborn, F.C.; Allamandola*, L.J.; Wooden, D.H.; Tielens, A.G.G.M.; Rank, D.M.; de Muizon, M.
Airborne observations of the infrared emission bands.
In: *Infrared Spectroscopy in Astronomy* (Kaldeich, B.H., Ed.). Paris: European Space Agency, p. 149-154, 1989. (ESA-SP-290) (GWU 11391)
- Cohen, M.; Tielens, A.G.G.M.; Bregman, J.; Witteborn, F.C.; Rank, D.M.; Allamandola*, L.J.; Wooden, D.H.; de Muizon, M.
The infrared emission bands. III. Southern *IRAS* sources.
Astrophysical Journal 341: 246-269, 1989. (GWU 11390)
- Cohen, M.; Wooden, D.; Tielens, A.G.G.M.; Bregman, J.; Witteborn, F.; Rank, D.; Allamandola*, L.J.
Airborne observations of the infrared emission bands.
In: *Interstellar Dust: Contributed Papers* (Tielens, A.G.G.M., Allamandola, L.J., Eds.). Moffett Field, CA: NASA, Ames Research Center, p. 93, 1989. (NASA-CP-3036) (GWU 11381)
- Cronin*, J.R.
Amino acids and bolide impacts.
Nature 339: 423-424, 1989. (GWU 11273)
- Cronin*, J.R.
Analysis of organic compounds in returned comet nucleus samples.
In: *Workshop on Analysis of Returned Comet Nucleus Samples*, Milpitas, CA, January 16-18, 1989, p. 16-17. (GWU 11404)
- Cronin*, J.R.
Origin of organic compounds in carbonaceous chondrites (Abstract).
In: *Abstracts of Papers, Annual Meeting of the American Association for the Advancement of Science*, San Francisco, CA, January 14-19, 1989, p. 24. (GWU 11403)
- Cronin*, J.R.
Origin of organic compounds in carbonaceous chondrites.
Advances in Space Research 9(2): 59-64, 1989. (GWU 11405)
- DeFrees*, D.J.; McLean, A.D.
A priori predictions of the rotational constants for HC₁₃N, HC₁₅N, C₅O.
Chemical Physics Letters 158: 540-544, 1989. (GWU 11412)

DeFrees*, D.J.; Miller, M.D.

The effect of ionization on the infrared absorption spectra of PAHs: A preliminary report.
In: *Interstellar Dust: Contributed Papers* (Tielens, A.G.G.M., Allamandola, L.J., Eds.).
Moffett Field, CA: NASA, Ames Research Center, p. 173-176, 1989. (NASA-CP-3036)
(GWU 11410)

Freund, F.; Batllo, F.; Freund, M.M. (Bunch, T.E. = P.I.)

Dissociation and recombination of positive holes in minerals.

In: *Spectroscopic Characterization of Minerals and Their Surfaces* (Coyne, L.M.,
McKeever, S.W.S., Blake, D.F., Eds.). Washington, DC: American Chemical Society, p.
310-329, 1989. (GWU 11598)

Geballe, T.R.; Tielens, A.G.G.M.; Allamandola*, L.J.; Moorhouse, A.; Brand, P.W.J.L.

Spatial variations of the 3 micron emission features within UV-excited nebulae:

Photochemical evolution of interstellar polycyclic aromatic hydrocarbons.

Astrophysical Journal 341: 278-287, 1989. (GWU 11388)

Gibson*, E.K., Jr.; Carr, R.H.

Laser microprobe-quadrupole mass spectrometer system for the analysis of gases and
volatiles from geologic materials.

In: *New Frontiers in Stable Isotopic Research: Laser Probes, Ion Probes, and Small-
Sample Analysis* (Shanks, W.C., III, Criss, R.E., Eds.). Denver, CO: U.S. Geological
Survey, p. 35-49, 1989. (GWU 11474)

Gibson*, E.K., Jr.; Hartmetz, C.P.; Blanford, G.E.

Analysis of interplanetary dust particles for volatiles and simple molecules (Abstract).

Lunar and Planetary Science Conference XX: 339-340, 1989. (GWU 11626)

Grady, M.M.; Gibson*, E.K., Jr.; Wright, I.P.; Pillinger, C.T.

The formation of weathering products on the LEW 85320 ordinary chondrite: Evidence
from carbon and oxygen stable isotope compositions and implications for carbonates in
SNC meteorites.

Meteoritics 24: 1-7, 1989. (GWU 11470)

Hartmetz, C.P.; Blanford, G.E.; Gibson*, E.K., Jr.

In situ analysis of volatile elements and molecules in carbonaceous chondrites (Abstract).

Lunar and Planetary Science Conference XX: 381-382, 1989. (GWU 11627)

Hartmetz, C.P.; Gibson*, E.K., Jr.

In situ determination of volatiles in CM2 chondrites (Abstract).

Meteoritics 24: 275, 1989. (GWU 11472)

Hartmetz, C.P.; Gibson*, E.K., Jr.; Socki, R.A.

Total carbon and sulfur abundances in Antarctic carbonaceous chondrites, ordinary
chondrites, and eucrites (Abstract).

Meteoritics 24: 274-275, 1989. (GWU 11473)

Herbst, E.; DeFrees*, D.J.; Koch, W.

Can interstellar H₂S be formed via gas-phase reactions? Calculations concerning the rates
of the ternary and radiative association reactions between HS⁺ and H₂.

Monthly Notices of the Royal Astronomical Society 237: 1057-1065, 1989.
(GWU 11411)

Herbst, E.; Winnewisser, G.; Yamada, K.M.T.; DeFrees*, D.J.; McLean, A.D.
Ab initio determination of mode coupling in HSSH: The torsional splitting in the first excited S-S stretching state.

Journal of Chemical Physics 91(10): 5905-5909, 1989. (GWU 11413)

Irvine*, W.M.

Microwave spectroscopy of astrophysical molecules.

Highlights of Astronomy 8: 339-343, 1989. (GWU 11633)

Irvine*, W.M.

Observational astrochemistry: Recent results.

Advances in Space Research 9(2): 3-12, 1989. (GWU 9005)

Irvine*, W.M.; Friberg, P.; Kaifu, N.; Kawaguchi, K.; Kitamura, Y.; Matthews, H.E.; Minh, Y.; Saito, S.; Ukita, N.; Yamamoto, S.

Observations of some oxygen-containing and sulfur-containing organic molecules in cold dark clouds.

Astrophysical Journal 342: 871-875, 1989. (GWU 11328)

Irvine*, W.M.; Knacke, R.F.

The chemistry of interstellar gas and grains.

In: *Origin and Evolution of Planetary and Satellite Atmospheres* (Atreya, S.K., Pollack, J.B., Matthews, M., Eds.). Tucson, AZ: University of Arizona Press, p. 3-34, 1989. (GWU 11320)

Knacke, R.F.; Kim, Y.H.; Irvine*, W.M.

An upper limit to the acetylene abundance toward BN in the Orion molecular cloud.

Astrophysical Journal 345: 265-267, 1989. (GWU 11325)

Koch, W.; Liu, B.; DeFrees*, D.J.

Structure of the 2-norbornyl cation.

Journal of American Chemical Society 111: 1527-1528, 1989. (GWU 11644)

Koch, W.; Liu, B.; DeFrees*, D.J.; Sunko, D.E.; Vancik, H.

Experimental and theoretical IR spectra of the 2-norbornyl cation.

Angewandte Chemie: International Edition in English 29(2): 183-185, 1989. (GWU 11622)

Koch, W.; Liu, B.; Scheiner, A.C.; DeFrees*, D.J.

Adaptation and vectorization of the Gaussian 86 quantum chemical program for the IBM 3090 with vector facility.

In: *High Performance Computing* (Delhay, J.-L., Gelenbe, E., Eds.). Amsterdam: Elsevier Science Publishers B.V., p. 261-272, 1989. (GWU 11625)

Krishna-Swamy, K.S.; Sandford, S.A.; Allamandola*, L.J.; Witteborn, F.C.;

Bregman, J.D.

The nature of cometary dust as determined from infrared observations.

In: *Interstellar Dust: Contributed Papers* (Tielens, A.G.G.M., Allamandola, L.J., Eds.). Moffett Field, CA: NASA, Ames Research Center, p. 415-416, 1989. (NASA-CP-3036) (GWU 11387)

- Krishna-Swamy, K.S.; Sandford, S.A.; Allamandola*, L.J.; Witteborn, F.C.; Bregman, J.D.
Infrared emission from comets.
Astrophysical Journal 340: 537-549, 1989. (GWU 11592)
- Lumme, K.; Peltoniemi, J.I.; Irvine*, W.M.
Derivation of an average single particle phase function for the lunar regolith (Abstract).
Lunar and Planetary Science Conference XX: 606-607, 1989. (GWU 11615)
- Madden, S.C.; Irvine*, W.M.; Matthews, H.E.; Friberg, P.; Swade, D.A.
A survey of cyclopropenylidene (C_3H_2) in galactic sources.
Astronomical Journal 97(5): 1403-1422, 1989. (GWU 11318)
- Minh, Y.C.; Irvine*, W.M.; Ziurys, L.M.
Detection of interstellar hydrogen sulfide in cold, dark clouds.
Astrophysical Journal (Letters) 345: L63-L66, 1989. (GWU 9598)
- Moorhouse, A.; Geballe, T.R.; Allamandola*, L.J.; Tielens, A.G.G.M.; Brand, P.W.J.L.
Spatial variations of the 3 μm emission features within nebulae.
In: *Interstellar Dust: Contributed Papers* (Tielens, A.G.G.M., Allamandola, L.J., Eds.).
Moffett Field, CA: NASA, Ames Research Center, p. 107, 1989. (NASA-CP-3036)
(GWU 11386)
- Muinenen, K.; Lumme, K.; Irvine*, W.M.
Statistical photoclinometry and surface topography of atmosphereless bodies (Abstract).
Lunar and Planetary Science Conference XX: 729-730, 1989. (GWU 11612)
- Peltoniemi, J.I.; Lumme, K.; Muinenen, K.; Irvine*, W.M.
Scattering of light by stochastically rough particles.
Applied Optics 28(19): 4088-4095, 1989. (GWU 11645)
- Sandford, S.A. (Allamandola, L.J. = P.I.)
Interstellar dust in collected interplanetary dust particles.
In: *Interstellar Dust: Contributed Papers* (Tielens, A.G.G.M., Allamandola, L.J., Eds.). Dordrecht, Holland: Kluwer, p. 403-413, 1989. (GWU 11382)
- Sandford, S.A.; Bradley, J.P. (Allamandola, L.J. = P.I.)
Interplanetary dust particles collected in the stratosphere: Observations of atmospheric heating and constraints on their interrelationships and sources.
Icarus 82: 146-166, 1989. (GWU 11591)
- Schutte, W.; Greenberg, M. (Allamandola, L.J. = P.I.)
The evolution of organic mantles on interstellar grains.
In: *Interstellar Dust: Contributed Papers* (Tielens, A.G.G.M., Allamandola, L.J., Eds.).
Moffett Field, CA: NASA, Ames Research Center, p. 267-268, 1989. (NASA-CP-3036)
(GWU 11379)
- Schutte, W.A.; Tielens, A.G.G.M. (Allamandola, L.J. = P.I.)
Theoretical studies of the infrared emission from circumstellar dust shells: The infrared characteristics of circumstellar silicates and the mass-loss rate of oxygen-rich late-type giants.
Astrophysical Journal 343: 369-392, 1989. (GWU 11383)

- Schwartz, P.R.; Snell, R.L.; Schloerb, F.P. (Irvine, W.M. = P.I.)
1300 micron continuum and C¹⁸O line mapping of giant molecular cloud cores. II. W3,
NGC 2264, NGC 6334I, RHO Ophiuchi and S140.
Astrophysical Journal 336: 519-525, 1989. (GWU 11327)
- Tielens, A.G.G.M. (Allamandola, L.J. = P.I.)
Dust in dense clouds.
In: *Interstellar Dust* (Allamandola, L.J., Tielens, A.G.G.M., Eds.). Dordrecht, Holland:
Kluwer, p. 239-262, 1989. (GWU 11385)
- Tielens, A.G.G.M.; Allamandola*, L.J. (Eds.)
Interstellar Dust: Contributed Papers. Moffett Field, CA: NASA, Ames Research Center,
588 p., 1989. (NASA-CP-3036) (GWU 11380)
- Van Der Zwet, G.P.; Allamandola*, L.J.; Baas, F.; Greenberg, J.M.
Infrared spectrum of the complex of formaldehyde with carbon dioxide in argon and
nitrogen matrices.
Journal of Molecular Structure 195: 213-225, 1989. (GWU 11384)
- Witteborn, F.C.; Sandford, S.A.; Bregman, J.D.; Allamandola*, L.J.; Cohen, M.;
Wooden, D.
Spectral structure near the 11.3 micron emission feature.
In: *Interstellar Dust: Contributed Papers* (Tielens, A.G.G.M., Allamandola, L.J., Eds.).
Moffett Field, CA: NASA, Ames Research Center, p. 119, 1989. (NASA-CP-3036)
(GWU 11590)
- Witteborn, F.C.; Sandford, S.A.; Bregman, J.D.; Allamandola*, L.J.; Cohen, M.;
Wooden, D.H.; Graps, A.L.
New emission features in the 11-13 micron region and their relationship to polycyclic
aromatic hydrocarbons.
Astrophysical Journal 341: 270-277, 1989. (GWU 11389)
- Yonover, R.N.; Sinton, J.M.; Sommer, M.A.; Gibson*, E.K.
C-O-H ratios in silicate melt inclusions in basalts from the Galapagos Spreading Center
near 95°W: A laser decrepitation mass spectrometry study.
Geochimica et Cosmochimica Acta 53: 3145-3154, 1989. (GWU 11471)
- Ziurys, L.M.; Friberg, P.; Irvine*, W.M.
Interstellar SiO as a tracer of high-temperature chemistry.
Astrophysical Journal 343: 201-207, 1989. (GWU 11323)
- Ziurys, L.M.; Snell, R.L.; Dickman, R.L. (Irvine, W.M. = P.I.)
Shock chemistry in the molecular clouds associated with SNR IC 443.
Astrophysical Journal 341: 857-866, 1989. (GWU 11326)

PREBIOTIC EVOLUTION

Armangue, G.; Mills, T.; Oro*, J.

Non-enzymatic oligomerization of dAMP and GTP and the condensation effects played by GTP (Abstract).

Origins of Life and Evolution of the Biosphere 19: 323-324, 1989. (GWU 8715)

Arrhenius*, G.; Bachman, J.; Gedulin, B.; Hui, S.; Paplawsky, W.

Anion selective minerals as concentrators and catalysts for RNA precursor components (Abstract).

Origins of Life and Evolution of the Biosphere 19: 235-236, 1989. (GWU 11392)

Chyba, C.; Sagan*, C.

The pre- and post- accretion irradiation history of cometary ices.

In: *Interstellar Dust: Contributed Papers* (Tielens, A.G.G.M., Allamandola, L.J., Eds.). Moffett Field, CA: NASA, Ames Research Center, p. 433-435, 1989. (NASA-CP-3036) (GWU 11568)

Chyba, C.F.; Sagan*, C.; Brookshaw, L.; Thomas, P.J.

Impact delivery of prebiotic organics to early Earth (Abstract).

Origins of Life and Evolution of the Biosphere 19: 467-468, 1989. (GWU 11686)

Chyba, C.F.; Sagan*, C.; Mumma, M.J.

The heliocentric evolution of cometary infrared spectra: Results from an organic grain model.

Icarus 79: 362-381, 1989. (GWU 11317)

Coyne*, L.M.; Banin, A.; Carle*, G.; Orenberg, J.; Scattergood*, T.

Use of near infrared correlation spectroscopy for quantitation of surface iron, absorbed water and stored electronic energy in a suite of Mars soil analog materials (Abstract).

In: *Exobiology and Future Mars Missions* (McKay, C.P., Davis, W.L., Eds.) Moffett Field, CA: NASA, Ames Research Center, p. 12, 1989. (NASA-CP-10027) (GWU 11942)

Coyne*, L.M.; Bishop, J.; Howard, L.; Banin, A.

Use of near infrared correlation spectroscopy to characterize and quantify surface water in variably Ca/Fe exchanged montmorillonite clays (Abstract).

In: *Program and Abstracts, California Catalysis Society Spring Meeting*, Stanford University, Palo Alto, CA, April 6-7, 1989, 2 p. (GWU 10167)

Coyne*, L.M.; Bishop, J.L.; Scattergood*, T.; Banin, A.; Carle*, G.; Orenberg, J.

Near-infrared correlation spectroscopy: Quantifying iron and surface water in a series of variably cation-exchanged montmorillonite clays.

In: *Spectroscopic Characterization of Minerals and Their Surfaces* (Coyne, L.M., McKeever, S.W.S., Blake, D.F., Eds.). Washington, DC: American Chemical Society, p. 407-429, 1989. (GWU 11597)

Coyne*, L.M.; Costanzo, P.M.; Theng, B.K.G.

Luminescence and ESR studies of relationships between O⁻-centres and structural iron in natural and synthetically hydrated kaolinites.

Clay and Clay Minerals 24: 671-693, 1989. (GWU 11401)

Coyne*, L.M.; McKeever, S.W.S.

Spectroscopic characterization of minerals and their surfaces.

In: *Spectroscopic Characterization of Minerals and Their Surfaces* (Coyne, L.M., McKeever, S.W.S., Blake, D.F., Eds.). Washington, DC: American Chemical Society, p. 1-29, 1989. (GWU 11400)

Coyne*, L.M.; McKeever, S.W.S.; Blake*, D.F. (Eds.)
Spectroscopic Characterization of Minerals and Their Surfaces. Washington, DC: American Chemical Society, 480 p., 1989. (GWU 11399)

Deamer*, D.W.
Amphiphilic components of carbonaceous meteorites: Origins of membrane structure (Abstract).
In: *Abstracts, Annual Meeting of the American Association for the Advancement of Science*, San Francisco, CA, January 14-19, 1989, p. 24. (GWU 11408)

Deamer*, D.W.; Harang, E.A.; Seleznev, S.A.
Amphiphilic components of carbonaceous meteorites: Origins of membrane structure (Abstract).
Origins of Life and Evolution of the Biosphere 19: 291-292, 1989. (GWU 11673)

Deamer*, D.W.; Pashley, R.M.
Amphiphilic components of the Murchison carbonaceous chondrite: Surface properties and membrane formation.
Origins of Life and Evolution of the Biosphere 19: 21-38, 1989. (GWU 11406)

Ertem, G.; Agarwal, V.; Ferris*, J.P.
The binding and clay mineral catalysis of the formation of oligomers of 5'-AMP in aqueous solution (Abstract).
Origins of Life and Evolution of the Biosphere 19: 347-348, 1989. (GWU 11677)

Ertem, G.; Ferris*, J.P.; Holm, N.G.
Adsorption of mono- and polynucleotides on iron oxide hydroxide polymorphs (Abstract).
Origins of Life and Evolution of the Biosphere 19: 349-350, 1989. (GWU 11678)

Feakes, C.R.; Holland*, H.D.; Zbinden, E.A.
Ordovician paleosols at Arisaig, Nova Scotia, and the evolution of the atmosphere.
In: *Paleopedology: Nature and Applications of Paleosols* (Bronger, A., Catt, J., Eds.). Cremlingen-Destedt, W. Germany: Catena Verlag, p. 207-232, 1989. (GWU 11482)

Ferris*, J.P.; Ertem, G.; Agarwal, V.
Mineral catalysis of the formation of dimers of 5'-AMP in aqueous solution: The possible role of montmorillonite clays in the prebiotic synthesis of RNA.
Origins of Life and Evolution of the Biosphere 19: 165-178, 1989. (GWU 11441)

Ferris*, J.P.; Ertem, G.; Agarwal, V.K.
The adsorption of nucleotides and polynucleotides on montmorillonite clay.
Origins of Life and Evolution of the Biosphere 19: 153-164, 1989. (GWU 11445)

Ferris*, J.P.; Ertem, G.; Kamaluddin; Agarwal, V.; Hua, L.L.
Mineral catalysis of the formation of the phosphodiester bond in aqueous solution: The possible role of montmorillonite clays.
Advances in Space Research 9(6): 67-75, 1989. (GWU 11446)

Ferris*, J.P.; Huang, C.-H.; Hagan, W.J., Jr.
N-cyanoimidazole and diimidazole imine: Water-soluble condensing agents for the formation of the phosphodiester bond.
Nucleosides & Nucleotides 8(3): 407-414, 1989. (GWU 11444)

- Ferris*, J.P.; Ishikawa, Y.; Rahman, K.
 Photolysis of ammonia in the presence of acetylene. A plausible explanation for the formation of HCN and chromophores on Jupiter (Abstract).
Origins of Life and Evolution of the Biosphere 19: 489-490, 1989. (GWU 11754)
- Ferris*, J.P.; Kamaluddin
 Oligomerization reactions of deoxyribonucleotides on montmorillonite clay: The effect of mononucleotide structure on phosphodiester bond formation.
Origins of Life and Evolution of the Biosphere 19: 609-619, 1989. (GWU 11618)
- Ferris*, J.P.; Kamaluddin; Kebbekus, P.; Ertem, G.; Hagan, W.J., Jr.
 RNA oligomer synthesis on mineral surfaces: Structural factors which influence oligomer formation on montmorillonite (Abstract).
Origins of Life and Evolution of the Biosphere 19: 325-326, 1989. (GWU 11675)
- Ferris*, J.P.; McCain, P.J.; Mendoza-Gomez, C.X.; Briggs, R.; Schutte, W.; Greenberg, J.M.; Ertem, G.
 Photochemical reactions on interstellar grains (Abstract).
Origins of Life and Evolution of the Biosphere 19: 463-464, 1989. (GWU 11442)
- Finney, S.A., Lt.; Tonks, W.B.; Melosh*, H.J.
 Statistical evolution of impact ejecta from the Earth: Implications for transfer to other solar system bodies (Abstract).
Lunar and Planetary Science Conference XX: 287-288, 1989. (GWU 11616)
- Fox*, S.W.
 The changing face of natural selection.
 In: *GAIA and Evolution* (Bunyard, P., Goldsmith, E., Eds.). Cornwall, England: Wadebridge Ecological Centre, p. 41-54, 1989.
- Fox*, S.W.
 From non-random molecular structure to life and mind.
Journal of Molecular Structure (Theochem) 199: 183-188, 1989. (GWU 11456)
- Fox*, S.W.
 Selfsequencing of amino acids: Prebiotic source of biological information (Abstract).
Origins of Life and Evolution of the Biosphere 19: 287-288, 1989. (GWU 11672)
- Frederick, C.A.; Quigley, G.J.; Teng, M.-K.; Coll, M.; van der Marel, G.A.; van Boom, J.H.; Rich*, A.; Wang, A.H.-J.
 Molecular structure of an A-DNA decamer d(ACCGGCCCGGT).
European Journal of Biochemistry 181(2): 295-307, 1989. (GWU 11647)
- Greenberg, J.M.; Zhao, N.; Hage, J. (Ferris, J.P. = P.I.)
 Chemical evolution of interstellar dust, comets and the origins of life.
Annales de Physique 14: 103-131, 1989. (GWU 11448)
- Guillemin, J.C.; Ferris*, J.P.
 Photochemical cycloaddition of cyanoacetylene and dicyanoacetylene (Abstract).
Origins of Life and Evolution of the Biosphere 19: 491-492, 1989. (GWU 11443)

- Harada, K.; Orgel*, L.
Oligomerization of 5'-deoxy-5'-nucleosideacetic acid derivatives (Abstract).
Origins of Life and Evolution of the Biosphere 19: 351-352, 1989. (GWU 11679)
- Holland*, H.D.; Feakes, C.R.
Paleosols and their relevance to precambrian atmospheric composition: A discussion.
Journal of Geology 97: 761-762, 1989. (GWU 11483)
- Holland*, H.D.; Feakes, C.R.; Zbinden, E.A.
The Flin Flon paleosol and the composition of the atmosphere 1.8 BYBP.
American Journal of Science 289: 362-389, 1989. (GWU 11481)
- Honda, Y.; Navarro-González, R.; Ponnampertuma*, C.
Chemical yields of biologically important compounds from electric discharges (Abstract).
Radiation Physics and Chemistry 33(3): 287, 1989. (GWU 11553)
- Honda, Y.; Navarro-González, R.; Ponnampertuma*, C.
A quantitative assay of biologically important compounds in simulated primitive Earth experiments.
Advances in Space Research 9(6): 63-66, 1989. (GWU 11557)
- Johnson, G.A.; Márquez, C.; Middleditch, B.S.; Zlatkis, A.; Oró*, J.
Aliphatic hydrocarbons obtained from iron carbides: Possible stellar and meteoritic implications (Abstract).
Origins of Life and Evolution of the Biosphere 19: 248-249, 1989. (GWU 8724)
- Kanavarioti*, A.; Bernasconi, C.F.; Doodokyan, D.L.; Alberas, D.
Magnesium ion catalyzed P-N bond hydrolysis in imidazolid activated nucleotides. Relevance to template-directed synthesis of polynucleotides (Abstract).
Origins of Life and Evolution of the Biosphere 19: 353, 1989. (GWU 11494)
- Kanavarioti*, A.; Bernasconi, C.F.; Doodokyan, D.L.; Alberas, D.J.
Magnesium ion catalyzed P-N bond hydrolysis in imidazolid-activated nucleotides. Relevance to template-directed synthesis of polynucleotides.
Journal of the American Chemical Society 111: 7247-7257, 1989. (GWU 11492)
- Kanavarioti*, A.; Chang*, S.
Limiting concentrations of activated mononucleotides necessary for template-directed oligonucleotide elongation (Abstract).
Origins of Life and Evolution of the Biosphere 19: 327-328, 1989. (GWU 11493)
- Kerridge*, J.F.
Deuterium enrichments and synthesis of meteoritic organic matter (Abstract).
Lunar and Planetary Science Conference XX: 516-517, 1989. (GWU 11501)
- Kerridge*, J.F.
Interstellar molecules in meteorites.
In: *Interstellar Dust* (Allamandola, L.J., Tielens, A.G.G.M., Eds.). Dordrecht, Holland: Kluwer, p. 383-388, 1989. (GWU 11500)
- Kerridge*, J.F.
Synthesis of meteoritic organic matter in an asteroid (Abstract).
Origins of Life and Evolution of the Biosphere 19: 505-506, 1989. (GWU 11757)

- Kerridge*, J.F.; Mariner, R.; Flores, J.; Chang*, S.
Isotopic characteristics of simulated meteoritic organic matter: 1. Kerogen-like material.
Origins of Life and Evolution of the Biosphere 19: 561-572, 1989. (GWU 11605)
- Khare*, B.N.; Sagan*, C.; Thompson, W.R.; Flynn, L.; Morrison, M.A.
Amino acids and their polymers in the lower clouds of Jupiter? Preliminary findings (Abstract).
Origins of Life and Evolution of the Biosphere 19: 495-496, 1989. (GWU 11755)
- Khare*, B.N.; Thompson, W.R.; Chyba, C.F.; Arakawa, E.T.; Sagan*, C.
Organic solids produced from simple C/H/O/N ices by charged particles: Applications to the outer solar system.
Advances in Space Research 9(2): 41-53, 1989. (GWU 11567)
- Khare*, B.N.; Thompson, W.R.; Murray, B.G.J.P.T.; Chyba, C.F.; Sagan*, C.
Solid organic residues produced by irradiation of hydrocarbon-containing H₂O and H₂O/NH₃ ices: Infrared spectroscopy and astronomical implications.
Icarus 79: 350-361, 1989. (GWU 11316)
- Kobayashi, K.; Hare, P.E.; Ponnamperna*, C.
Analysis of sugars in the products of spark discharge in simulated primitive atmospheres by GC-MS. (Japanese)
Bunseki Kagaku 38(11): 608-612, 1989. (GWU 11555)
- Kuma, K.; Paplawsky, W.; Gedulin, B.; Arrhenius*, G.
Mixed-valence hydroxides as bioorganic host minerals.
Origins of Life and Evolution of the Biosphere 19: 573-602, 1989. (GWU 11393)
- Lacey*, J.C., Jr.; Staves, M.P.
Did an ancestor of both 5S ribosomal RNA and transfer RNA function as a universal translator? (Abstract)
Origins of Life and Evolution of the Biosphere 19: 356, 1989. (GWU 11680)
- Lacey*, J.C., Jr.; Thomas, R.D.; Staves, M.P.; Minic, V.; Watkins, C.L.
Purine monoribonucleotides may preferentially catalyze the synthesis of L-amino acid peptides (Abstract).
Origins of Life and Evolution of the Biosphere 19: 332-333, 1989. (GWU 11676)
- Lazcano, A.; Gariglio, J.; Orozco, E.; Oró*, J.
On the early evolution of reverse-transcriptase (Abstract).
Origins of Life and Evolution of the Biosphere 19: 385-386, 1989. (GWU 8240)
- Lazcano, A.; Llaca, V.; Fox*, G.E.; Oro*, J.
A classification of RNA polymerases based on their evolutionary relatedness (Abstract).
Origins of Life and Evolution of the Biosphere 19: 407-408, 1989. (GWU 11453)
- Levine*, J.S.
Planetary atmospheres.
In: *Encyclopedia of Astronomy and Astrophysics* (Meyers, R.A., Ed.). New York: Academic Press, p. 361-389, 1989. (GWU 11624)

- MacElroy*, R.D.; Morowitz, H.; Pohorille, A.
Ion transport mechanisms and prebiotic membranes (Abstract).
Origins of Life and Evolution of the Biosphere 19: 295-296, 1989. (GWU 11674)
- Mar, A.; Oró*, J.
Synthesis of the coenzymes, ADPG, GDPG, and CDP-ethanolamine under primitive Earth conditions (Abstract).
Origins of Life and Evolution of the Biosphere 19: 254-255, 1989. (GWU 11671)
- McDonald, J.J.; Rein*, R.
Molecular modeling of calmodulin: A comparison with crystallographic data (Abstract).
Abstract of paper presented at the Sanibel Symposia, St. Augustine, FL, April 1-8, 1989, 1 p.
(GWU 11562)
- McDonald, J.J.; Rein*, R.
Molecular modeling of calmodulin: A comparison with crystallographic data (Abstract).
International Journal of Quantum Chemistry: Quantum Biology Symposium 16: 57-72, 1989.
(GWU 10761)
- Mendis, D.A.; Arrhenius*, G.
Electrodynamic control in planetesimal accretion.
Proceedings. A. Earth and Planetary Sciences. Indiana Academy of Science Lal Volume: 1-5, 1989.
- Mendoza-Gómez, C.X.; Greenberg, J.M.; McCain, P.; Ferris*, J.P.; Briggs, R.; de Groot, M.S.; Schutte, W.A.
Molecular and mass spectroscopic analysis of isotopically labeled organic residues.
In: *Interstellar Dust: Contributed Papers* (Tielens, A.G.G.M., Allamandola, L.J., Eds.). Moffett Field, CA: NASA, Ames Research Center, p. 257-260, 1989. (NASA-CP-3036) (GWU 11447)
- Michelangeli, D.V.; Allen, M.; Yung*, Y.L.
El Chichon volcanic aerosols: Impact of radiative, thermal, and chemical perturbations.
Journal of Geophysical Research 94(D15): 18429-18443, 1989. (GWU 11638)
- Miller*, S.L.; Bada, J.L.; Friedmann, N.
What was the role of submarine hot springs in the origin of life? (Abstract)
Origins of Life and Evolution of the Biosphere 19: 536-537, 1989. (GWU 11532)
- Navarro-González, R.; Negrón-Mendoza, A.; Aguirre-Calderón, M.E.; Ponnampereuma*, C.
The γ -irradiation of aqueous hydrogen cyanide in the presence of ferrocyanide or ferricyanide: Implications to prebiotic chemistry.
Advances in Space Research 9(6): 57-61, 1989. (GWU 11556)
- Navarro-González, R.; Negrón-Mendoza, A.; Ramos, S.; Ponnampereuma*, C.
Clay-mediated decarboxylation of acetic acid. The role of radiation heterogeneous catalysis in prebiotic chemistry (Abstract).
In: *Abstracts, Ninth International Clay Conference*, Strasbourg, France, August 28-September 2, 1989, p. 278. (GWU 11552)

- Oberbeck, V.R.; Fogleman, G. (Carle, G.C. = P.I.)
Effect of the late heavy bombardment of the terrestrial planets on chemical evolution on Earth and Mars (Abstract).
Origins of Life and Evolution of the Biosphere 19: 477-478, 1989. (GWU 11997)
- Oberbeck, V.R.; Fogleman, G. (Carle, G.C. = P.I.)
Estimates of the maximum time required to originate life.
Origins of Life and Evolution of the Biosphere 19: 549-560, 1989. (GWU 11431)
- Oberbeck, V.R.; Fogleman, G. (Carle, G.C. = P.I.)
Impacts and the origin of life.
Nature 339: 434, 1989. (GWU 11426)
- Oberbeck, V.R.; McKay*, C.P.; Scattergood*, T.W.; Carle*, G.C.; Valentin*, J.R.
The role of cometary particle coalescence in chemical evolution.
Origins of Life and Evolution of the Biosphere 19: 39-55, 1989. (GWU 11398)
- Orgel*, L.E.
Abiogenic synthesis of polynucleotides (Abstract).
Origins of Life and Evolution of the Biosphere 19: 319, 1989. (GWU 11750)
- Orgel*, L.E.
The origin of polynucleotide-directed protein synthesis.
Journal of Molecular Evolution 29: 465-474, 1989. (GWU 11535)
- Orgel*, L.E.
Was RNA the first genetic polymer?
In: *Evolutionary Tinkering in Gene Expression* (Grunberg-Manago, M., Clark, B.F.C., Zachau, H.G., Eds.). New York: Plenum Publishing, p. 215-224, 1989. (GWU 11533)
- Oró*, J.
Chemical evolution: A solar system perspective (Abstract).
In: *Exobiology and Future Mars Missions* (McKay, C.P., Davis, W.L., Eds.). Moffett Field, CA: NASA, Ames Research Center, p. 46-49, 1989. (GWU 11541)
- Oró*, J.; Mills, T.
Chemical evolution of primitive solar system bodies.
Advances in Space Research 9(2): 105-120, 1989. (GWU 11543)
- Peyser, J.R.; Ferris*, J.P.
Synthesis of deoxynucleotide dimers: A starting point for prebiotic studies (Abstract).
Origins of Life and Evolution of the Biosphere 19: 362-363, 1989. (GWU 11681)
- Pohorille, A.; MacElroy*, R.D.
Ions in aqueous solutions and at water interfaces: Supercomputer simulation tests of basic theories.
In: *Proceedings of the Fourth International Conference on Supercomputers* (Kantashev, L., Kantashev, S., Eds.). St. Petersburg, FL: International Supercomputing Institute, p. 49-56, 1989. (GWU 11608)

Ponnamperuma*, C.

Experimental studies in the origin of life.

Journal of the British Interplanetary Society 42: 397-400, 1989. (GWU 11559)

Rein*, R.; McDonald, J.

Use of theoretical and experimental approaches in modeling macromolecular complexes (Abstract).

Abstract of paper presented at the Workshop on High-Field NMR and Biological Applications, Pacific Northwest Laboratory, Richland, WA, September 8-9, 1989, 2 p. (GWU 11566)

Rein*, R.; Shibata, M.; McDonald, J.; McCourt, M.; Zielinski, T.

Study of nucleic acids and protein structure and function by methods of computational chemistry (Abstract).

Abstract of paper presented at 8th Annual Conference of the Molecular Graphics Society, St. Andrews, Scotland, March 29-31, 1989, 1 p. (GWU 11563)

Scattergood*, T.W.; McKay*, C.P.; Borucki, W.J.; Giver, L.P.; Van Ghyseghem, H.;

Parris, J.E.; Miller*, S.L.

Production of organic compounds in plasmas: A comparison among electric sparks, laser-induced plasmas, and UV light.

Icarus 81: 413-428, 1989. (GWU 11528)

Schwartz, A.W. (Orgel, L.E. = P.I.)

Models for the origins of RNA molecules (Abstract).

Origins of Life and Evolution of the Biosphere 19: 322, 1989. (GWU 11999)

Schwartz, A.W. (Orgel, L.E. = P.I.)

Nucleic acid analogues and the origins of replication.

Advances in Space Research 9(6): 77-81, 1989. (GWU 12001)

Schwartz, A.W.; Bakker, C.G. (Orgel, L.E. = P.I.)

Was adenine the first purine?

Science 245: 1102-1104, 1989. (GWU 10463)

Shen, C.; Lazcano, A.; Oro*, J.

On the prebiological significance of the catalytic activity of histidyl-histidine (Abstract).

Origins of Life and Evolution of the Biosphere 19: 415, 1989. (GWU 11080)

Shen, C.; Yang, L.; Miller*, S.L.; Oro*, J.

The prebiotic synthesis of histidine and histidyl-histidine (Abstract).

Origins of Life and Evolution of the Biosphere 19: 258-259, 1989. (GWU 11529)

Shia, R.-L.; Yung*, Y.L.; Allen, M.; Zurek, R.W.; Crisp, D.

Sensitivity study of advection and diffusion coefficients in a two-dimensional stratospheric model using excess carbon 14 data.

Journal of Geophysical Research 94(D15): 18467-18484, 1989. (GWU 11639)

Shibata, M.; Rein*, R.

A computer modeling study of acetylcholine receptor-ligand interactions.

In: *Computer Assisted Modeling of Receptor-Ligand Interactions: Theoretical Aspects and*

Applications to Drug Design (Rein, R., Golembek, A., Eds.). New York: Alan R. Liss, p. 39-54, 1989. (GWU 11565)

- Staves, M.P.; Lacey*, J.C., Jr.
On the probability of a common origin for tRNA and 5S rRNA.
Zeitschrift für Naturforschung 44c: 296-306, 1989. (GWU 11312)
- Stribling, R.; Miller*, S.L.
Attempted non-enzymatic template-directed polymerizations of uridine and uridine analogs on polyadenosine: Implications for the nature of the first genetic material (Abstract).
Origins of Life and Evolution of the Biosphere 19: 329-330, 1989. (GWU 11531)
- Su, Y.-L.; Honda, Y.; Hare, P.E.; Ponnamperna*, C.
Search of peptide-like materials in electric discharge experiments (Abstract).
Origins of Life and Evolution of the Biosphere 19: 237-238, 1989. (GWU 11648)
- Thompson, W.R.; Sagan*, C.
Atmospheric formation of organic heteropolymers from $N_2 + CH_4$: Structural suggestions for amino acid and oligomer precursors (Abstract).
Origins of Life and Evolution of the Biosphere 19: 503-504, 1989. (GWU 11756)
- Tohidi, M.; Orgel*, L.E.
Some acyclic analogues of nucleotides and their template-directed reactions.
Journal of Molecular Evolution 28: 367-373, 1989. (GWU 11536)
- Tonks, W.B.; Melosh*, H.J.
Mass exchange among the terrestrial planets: Implications for life exchange between Earth and Mars (Abstract).
Eos 70: 1173, 1989. (GWU 11527)
- Visscher, J.; van der Woerd, R.; Bakker, C.G.; Schwartz, A.W. (Orgel, L.E. = P.I.)
Oligomerization of deoxynucleoside-bisphosphate dimers: Template and linkage specificity.
Origins of Life and Evolution of the Biosphere 19: 3-6, 1989. (GWU 11996)
- Wade, R.C.; Powers, J.V.; Ponnamperna*, C.
Chemical evolution and the origin of life: Bibliography Supplement 1985.
Origins of Life and Evolution of the Biosphere 19: 199-220, 1989. (GWU 11994)
- Weber*, A.L.
Glyceraldehyde as a source of energy and matter for the origin of life (Abstract).
Origins of Life and Evolution of the Biosphere 19: 317-318, 1989. (GWU 11578)
- Weber*, A.L.
Model of early self-replication based on covalent complementarity for a copolymer of glycerate-3-phosphate and glycerol-3-phosphate.
Origins of Life and Evolution of the Biosphere 19: 179-186, 1989. (GWU 11580)
- Weber*, A.L.
Thermal synthesis and hydrolysis of polyglyceric acid.
Origins of Life and Evolution of the Biosphere 19: 7-19, 1989. (GWU 11579)
- Wen, J.-S.; Pinto, J.P.; Yung*, Y.L.
Photochemistry of CO and H_2O : Analysis of laboratory experiments and applications to the prebiotic Earth's atmosphere.
Journal of Geophysical Research 94(D12): 14957-14970, 1989. (GWU 11587)

Wilson, M.A.; Pohorille, A.; Pratt, L.R. (MacElroy, R.D. = P.I.)
Comment on "Study on the liquid-vapor interface of water. I. Simulation results of
thermodynamic properties and orientational structure."
Journal of Chemical Physics 90(9): 5211-5213, 1989. (GWU 11428)

Wilson, M.A.; Pohorille, A.; Pratt, L.R. (MacElroy, R.D. = P.I.)
Interaction of a sodium ion with the water liquid-vapor interface.
Chemical Physics 129: 209-212, 1989. (GWU 11435)

Yung*, Y.L.; Wen, J.-S.; Moses, J.I.; Landry, B.M.; Allen, M.; Hsu, K.-J.
Hydrogen and deuterium loss from the terrestrial atmosphere: A quantitative assessment of
nonthermal escape fluxes.
Journal of Geophysical Research 94(D12): 14971-14989, 1989. (GWU 11589)

Zumwalt, R.W.; Gehrke, C.W.; Ponnampertuma*, C.
Instruments and analyses.
In: *Ninth College Park Colloquium on Chemical Evolution*, College Park, MD, October 29-31,
1989, p. 35-36. (GWU 11554)

EARLY EVOLUTION OF LIFE

- Ammons, D.; Ward, S.; Klass, M.; Fox*, G.E.
Evolution of the MSP multigene family in the nematode *Caenorhabditis elegans* (Abstract).
Worm Breeders Gazette 11: 45-46, 1989. (GWU 11454)
- Beier, J.A.; Hayes*, J.M.
Geochemical and isotopic evidence for paleoredox conditions during deposition of the Devonian-Mississippian New Albany Shale, southern Indiana.
Geological Society of America Bulletin 101: 774-782, 1989. (GWU 11646)
- Berner, R.A.; Canfield, D.E. (DeVincenzi, D.L. = P.I.)
A new model for atmospheric oxygen over Phanerozoic time.
American Journal of Science 289: 333-361, 1989. (GWU 11424)
- Boreham, C.J.; Fookes, C.J.R.; Popp, B.N.; Hayes*, J.M.
Origins of etioporphyrins in sediments: Evidence from stable carbon isotopes.
Geochimica et Cosmochimica Acta 53: 2451-2455, 1989. (GWU 11276)
- Buchanan*, B.B.; Hartman, H.; Syvanen, M.
Evolutionary history of chloroplast thioredoxins f and m (Abstract).
Plant Physiology 89(4, Suppl.): 174, 1989. (GWU 11395)
- Byerly, G.R.; Lowe*, D.R.; Kroner, A.
A complex and prolonged magmatic evolution for the Barberton Greenstone Belt, South Africa (Abstract).
Eos 70: 1391, 1989. (GWU 11510)
- Canfield, D.E. (DeVincenzi, D.L. = P.I.)
Reactive iron in marine sediments.
Geochimica et Cosmochimica Acta 53: 619-632, 1989. (GWU 11434)
- Canfield, D.E. (DeVincenzi, D.L. = P.I.)
Sulfate reduction and oxic respiration in marine sediments: Implications for organic carbon preservation in euxinic environments.
Deep-Sea Research 36(1): 121-138, 1989. (GWU 11433)
- D'Antoni-D'Amelio, E.; Cohen, Y.; Des Marais*, D.J.
Comparative functional ultrastructure of two hypersaline submerged cyanobacterial mats: Guerrero Negro, Baja California Sur, Mexico, and Solar Lake, Sinai, Egypt.
In: *Microbial Mats: Physiological Ecology of Benthic Microbial Communities* (Cohen, Y., Rosenberg, E., Eds.). Washington, DC: American Society for Microbiology, p. 97-113, 1989. (GWU 11415)
- Deamer*, D.; Mikhailov, A.I.; Seleznev, S.A.
How the first cells appeared. (Russian)
Priroda 10: 3-9, 1989. (GWU 11407)
- Derry, L.A.; Keto, L.S.; Jacobsen, S.B.; Knoll*, A.H.; Swett, K.
Sr isotopic variations in Upper Proterozoic carbonates from Svalbard and East Greenland.
Geochimica et Cosmochimica Acta 53: 2331-2339, 1989. (GWU 11505)

- Des Marais*, D.J.
Stable carbon and sulfur isotopes as records of the early biosphere (Abstract).
In: *Exobiology and Future Mars Missions* (McKay, C.P., Davis, W.L., Eds.) Moffett Field, CA: NASA, Ames Research Center, p. 15-16, 1989. (NASA-CP-10027) (GWU 11941)
- Des Marais*, D.J.; Cohen, Y.; Nguyen, H.; Cheatham, M.; Cheatham, T.; Munoz, E.
Carbon isotopic trends in the hypersaline ponds and microbial mats at Guerrero Negro, Baja California Sur, Mexico: Implications for Precambrian stromatolites.
In: *Microbial Mats: Physiological Ecology of Benthic Microbial Communities* (Cohen, Y., Rosenberg, E., Eds.). Washington, DC: American Society for Microbiology, p. 191-203, 1989. (GWU 11416)
- Enzien, M.; McKhann, H.I.; Margulis*, L.
Ecology and life history of an amoebomastigote, *Paratetramitus jugosus*, from a microbial mat: New evidence for multiple fission.
Biological Bulletin 177: 110-129, 1989. (GWU 11619)
- Freeman, K.H.; Ricci, M.P.; Studley, S.A.; Hayes*, J.M.
Isotope ratio monitoring gas chromatography mass spectrometry (IRM-GCMS) (Abstract).
In: *Exobiology and Future Mars Missions* (McKay, C.P., Davis, W.L., Eds.) Moffett Field, CA: NASA, Ames Research Center, p. 20-21, 1989. (NASA-CP-10027) (GWU 11940)
- Friedmann*, E.I.
What is an extreme environment? (Abstract)
In: *Abstracts, Fifth International Symposium on Microbial Ecology*, Kyoto, Japan, 1989, p. 56. (GWU 11469)
- Friedmann*, E.I.; Friedmann, R.O.
Microbial trace fossils in Antarctica and the search for evidence of early life on Mars (Abstract).
In: *Exobiology and Future Mars Missions* (McKay, C.P., Davis, W.L., Eds.) Moffett Field, CA: NASA, Ames Research Center, p. 22, 1989. (NASA-CP-10027) (GWU 11939)
- Friedmann*, E.I.; Koriem, A.M.
Life on Mars: How it disappeared (If it was ever there).
Advances in Space Research 9(6): 167-172, 1989. (GWU 11461)
- Friedmann*, E.I.; Meyer, M.A.; Friedmann, R.O.; Kappen, L.
Antarctic microorganisms: Optimal temperature for species may be lethal for the community (Abstract).
In: *Abstracts, 9th International Symposium on Environmental Biogeochemistry*, Moscow, USSR, September 4-8, 1989, No. 175. (GWU 11468)
- Friedmann*, E.I.; Meyer, M.A.; Friedmann, R.O.; Kappen, L.
Antarctic microorganisms: Optimal temperature for species may be lethal for the community (Abstract).
In: *Abstracts of the 89th Annual Meeting of the American Society for Microbiology*, New Orleans, LA, May 14-19, 1989, p. 230. (GWU 11466)
- Gelwicks, J.T.; Risatti, J.B.; Hayes*, J.M.
Carbon isotope effects associated with autotrophic acetogenesis.
Organic Geochemistry 14(4): 441-446, 1989. (GWU 11313)

- Green, J.W.; Knoll*, A.H.; Swett, K.
Microfossils from silicified stromatolitic carbonates of the Upper Proterozoic Limestone-Dolomite 'Series,' central East Greenland.
Geological Magazine 126(5): 567-585, 1989. (GWU 11506)
- Green, W.J.; Ferdelman, T.G.; Canfield, D.E. (DeVincenzi, D.L. = P.I.)
Metal dynamics in Lake Vanda (Wright Valley, Antarctica).
Chemical Geology 76: 85-94, 1989. (GWU 11427)
- Hadwiger, M.A.; Fox*, G.E.
Distances as degrees of freedom.
Journal of Biomolecular Structure & Dynamics 7(3): 749-771, 1989. (GWU 11452)
- Haselman, T.; Camp, D.G.; Fox*, G.E.
Phylogenetic evidence for tertiary interactions in 16S-like ribosomal RNA.
Nucleic Acids Research 17(6): 2215-2221, 1989. (GWU 11450)
- Haselman, T.; Gutell, R.R.; Jurka, J.; Fox*, G.E.
Additional Watson-Crick interactions suggest a structural core in large subunit ribosomal RNA.
Journal of Biomolecular Structure & Dynamics 7(1): 181-186, 1989. (GWU 11451)
- Hayes*, J.M.; Popp, B.N.; Takigiku, R.; Johnson, M.W.
An isotopic study of biogeochemical relationships between carbonates and organic carbon in the Greenhorn Formation.
Geochimica et Cosmochimica Acta 53: 2961-2972, 1989. (GWU 11277)
- Hinkle, G.; Margulis*, L.
Non-Mendelian genetic systems.
Genome 31: 486-487, 1989. (GWU 11637)
- Hunten, D.M.; Donahue, T.M.; Walker*, J.C.G.; Kasting*, J.F.
Escape of atmospheres and loss of water.
In: *Origin and Evolution of Planetary and Satellite Atmospheres* (Atreya, S.K., Pollack, J.B., Matthews, M.S., Eds.). Tucson, AZ: University of Arizona Press, p. 386-422, 1989. (GWU 11499)
- Huppe, H.C.; Buchanan*, B.B.
Activation of a chloroplast type of fructose biphosphatase from *Chlamydomonas reinhardtii* by light-mediated agents.
Zeitschrift für Naturforschung 44c: 487-494, 1989. (GWU 11311)
- Jahnke*, L.L.; Diggs, K.
Evidence for the synthesis of the multi-positional isomers of monounsaturated fatty acid in *Methylococcus capsusatus* by the anaerobic pathway.
FEMS Microbiology Letters 58: 183-188, 1989. (GWU 11484)
- Jahnke*, L.L.; Lee, B.; Sweeney, M.J.; Klein*, H.P.
Anaerobic biosynthesis of unsaturated fatty acids in the cyanobacterium, *Oscillatoria limnetica*.
Archives of Microbiology 152: 215-217, 1989. (GWU 11485)

- Johnston, C.G.; Vestal, J.R. (Friedmann, E.I. = P.I.)
Distribution of inorganic species in two Antarctic cryptoendolithic microbial communities.
Geomicrobiology Journal 7: 137-153, 1989. (GWU 11458)
- Kasting*, J.F.
Carbon oxidation state in the early atmosphere: CO₂ or CO? (Abstract)
Origins of Life and Evolution of the Biosphere 19: 225-226, 1989. (GWU 11669)
- Kasting*, J.F.
Long-term stability of the Earth's climate.
Palaeogeography, Palaeoclimatology, Palaeoecology 75: 83-95, 1989. (GWU 11495)
- Kasting*, J.F.; Toon, O.B.
Climate evolution on the terrestrial planets.
In: *Origin and Evolution of Planetary and Satellite Atmospheres* (Atreya, S.K., Pollack, J.B., Matthews, M.S., Eds.). Tucson, AZ: University of Arizona Press, p. 423-449, 1989.
(GWU 11498)
- Kasting*, J.F.; Zahnle, K.J.; Pinto, J.P.; Young, A.T.
Sulfur, ultraviolet radiation, and the early evolution of life (Abstract).
Origins of Life and Evolution of the Biosphere 19: 252-253, 1989. (GWU 11670)
- Kasting*, J.F.; Zahnle, K.J.; Pinto, J.P.; Young, A.T.
Sulfur, ultraviolet radiation, and the early evolution of life.
Origins of Life and Evolution of the Biosphere 19: 95-108, 1989. (GWU 11496)
- Knoll*, A.H.
Evolution and extinction in the marine realm: Some constraints imposed by phytoplankton.
Philosophical Transactions of the Royal Society of London B325: 279-290, 1989. (GWU 11508)
- Knoll*, A.H.
The paleomicrobiological information in proterozoic rocks.
In: *Microbial Mats: Physiological Ecology of Benthic Microbial Communities* (Cohen, Y., Rosenberg, E., Eds.). Washington, DC.: American Society for Microbiology, p. 469-484, 1989.
(GWU 11504)
- Knoll*, A.H.; Bauld, J.
The evolution of ecological tolerance in prokaryotes.
Transactions of the Royal Society of Edinburgh: Earth Sciences 80: 209-223, 1989.
(GWU 11507)
- Knoll*, A.H.; Butterfield, N.J.
New window on Proterozoic life.
Nature 337: 602-603, 1989. (GWU 10279)
- Knoll*, A.H.; Swett, K.; Burkhardt, E.
Paleoenvironmental distribution of microfossils and stromatolites in the Upper Proterozoic Backlundtoppen Formation, Spitsbergen.
Journal of Paleontology 63(2): 129-145, 1989. (GWU 10270)

- Kretsinger*, R.H.; Moncrief, N.D.
Evolution of calcium modulated proteins.
Virginia Explorer 5(5): 7-9, 1989. (GWU 11629)
- Kröner, A.; Byerly, G.R.; Lowe*, D.R.
Precise single zircon evaporation ages documenting = 200 Ma of Archean greenstone evolution in the Barberton Belt of South Africa (Abstract).
Eos 70: 1404, 1989. (GWU 11509)
- Kuhn, W.R.; Walker*, J.C.G.; Marshall, H.G.
The effect on Earth's surface temperature from variations in rotation rate, continent formation, solar luminosity, and carbon dioxide.
Journal of Geophysical Research 94(D8): 11129-11136, 1989. (GWU 11635)
- Lang, F.; Hochstein*, L.I.
Are Archaeobacteria appropriate models for studying the early evolution of life? The enzyme nitrate reductase as a case in point (Abstract).
Origins of Life and Evolution of the Biosphere 19: 389-390, 1989. (GWU 11683)
- Lowe*, D.R.
The geological record of life 3500 Ma ago: Coping with the rigors of a young Earth during late accretion (Abstract).
In: *Exobiology and Future Mars Missions* (McKay, C.P., Davis, W.L., Eds.) Moffett Field, CA: NASA, Ames Research Center, p. 40-41, 1989. (NASA-CP-10027) (GWU 11932)
- Lowe*, D.R.; Byerly, G.R.; Asaro*, F.; Kyte, F.J.
Geological and geochemical record of 3400-million-year-old terrestrial meteorite impacts.
Science 245: 959-962, 1989. (GWU 8673)
- Madigan, M.T.; Takigiku, R.; Lee, R.G.; Gest, H.; Hayes*, J.M.
Carbon isotope fractionation by thermophilic phototrophic sulfur bacteria: Evidence for autotrophic growth in natural populations.
Applied and Environmental Microbiology 55(3): 639-644, 1989. (GWU 11330)
- Mancinelli*, R.L.
Nitrogen cycling in microbial mats beneath an Antarctic perennially ice-covered lake. Presented at the Fifth International Symposium on Microbial Ecology, p. 86, 1989.
- Mancinelli*, R.L.
The role of nitrogen in the evolution of life (Abstract).
Origins of Life and Evolution of the Biosphere 19: 387-388, 1989. (GWU 11682)
- Margulis*, L.; Guerrero, R.
From planetary atmospheres to microbial communities: A stroll through space and time.
In: *Changing the Global Environment: Perspectives on Human Involvement* (Botkin, D.B., Estes, J.E., Caswell, M.F., Orio, A.A., Eds.). New York: Academic Press, p. 51-67, 1989. (GWU 10109)
- Margulis*, L.; Lovelock, J.E.
Gaia and geognosy.
In: *Global Ecology: Towards a Science in the Biosphere* (Rambler, M.B., Margulis, L., Fester, R., Eds.). New York: Academic Press, p. 1-30, 1989. (GWU 11414)

- Margulis*, L.; Nealson, K.H.
Symbiosis as the source of evolutionary innovation.
Endocytobiosis and Cell Research 6(2-3): 235-239, 1989.
- Meyer, M.A.; Friedmann*, E.I.; Kappen, L.; Nienow, J.A.; Sun, H.J.
Long term production in the Antarctic cryptoendolithic microbial ecosystem (Abstract).
In: *Abstracts of the 89th Annual Meeting of the American Society for Microbiology*, New Orleans, LA, May 14-19, 1989, p. 230. (GWU 11467)
- Navarro-González, R.; Ponnamperna*, C.
El mecanismo de la bioluminiscencia bacteriana. (Spanish)
Revista de la Sociedad Química de México 33(2): 54-60, 1989. (GWU 11558)
- Noll, K.M. (Woese, C.R. = P.I.)
Chromosome map of thermophilic archaeobacterium *Thermococcus celer*.
Journal of Bacteriology 171(12): 6720-6725, 1989. (GWU 11583)
- Ocampo, R.; Callot, H.J.; Albrecht, P.; Popp, B.N.; Horowitz, M.R.; Hayes*, J.
Different isotope compositions of C₃₂ DPEP and C₃₂ etioporphyrin III in oil shale.
Naturwissenschaften 76: 419-421, 1989. (GWU 11278)
- Olsen, G.J.; Woese*, C.R.
A brief note concerning archaeobacterial phylogeny.
Canadian Journal of Microbiology 35: 119-123, 1989. (GWU 11582)
- Osawa, S.; Jukes*, T.H.
Codon reassignment (codon capture) in evolution.
Journal of Molecular Evolution 28: 271-278, 1989. (GWU 11486)
- Osawa, S.; Ohama, T.; Jukes*, T.H.; Watanabe, K.
Evolution of the mitochondrial genetic code. I. Origin of AGR serine and stop codons in metazoan mitochondria.
Journal of Molecular Evolution 29: 202-207, 1989. (GWU 11488)
- Osawa, S.; Ohama, T.; Jukes*, T.H.; Watanabe, K.; Yokoyama, S.
Evolution of the mitochondrial genetic code. II. Reassignment of codon AUA from isoleucine to methionine.
Journal of Molecular Evolution 29: 373-380, 1989. (GWU 11489)
- Palmisano, A.C.; Cronin, S.E.; D'Amelio, E.D.; Munoz, E.; Des Marais*, D.J.
Distribution and survival of lipophilic pigments in a laminated microbial mat community near Guerrero Negro, Mexico.
In: *Microbial Mats: Physiological Ecology of Benthic Microbial Communities* (Cohen, Y., Rosenberg, E., Eds.). Washington, DC: American Society for Microbiology, p. 138-152, 1989. (GWU 11417)
- Palmisano, A.C.; Summons, R.E.; Cronin, S.E.; Des Marais*, D.J.
Lipophilic pigments from cyanobacterial (blue-green algal) and diatom mats in Hamelin Pool, Shark Bay, Western Australia.
Journal of Phycology 25: 655-661, 1989. (GWU 11420)

- Palmisano, A.C.; Wharton*, R.A., Jr.; Cronin, S.E.; Des Marais*, D.J.
Lipophilic pigments from the benthos of a perennially ice-covered Antarctic Lake.
Hydrobiologia 178: 73-80, 1989. (GWU 11419)
- Pande, C.; Lanyi*, J.K.; Callender, R.H.
Effects of various anions on the Raman spectrum of halorhodopsin.
Biophysical Journal 55(3): 425-431, 1989. (GWU 11664)
- Persechini, A.; Moncrief, N.D.; Kretsinger*, R.H.
The EF-hand family of calcium-modulated proteins.
Trends in Neurological Sciences 12(11): 462-467, 1989. (GWU 11279)
- Popp, B.N.; Takigiku, R.; Hayes*, J.M.; Louda, J.W.; Baker, E.W.
The post-Paleozoic chronology and mechanism of ^{13}C depletion in primary marine organic matter.
American Journal of Science 289: 436-454, 1989. (GWU 11275)
- Rau, G.H.; Takahashi, T.; Des Marais*, D.J.
Latitudinal variations in plankton $\delta^{13}\text{C}$: Implications for CO_2 and productivity in past oceans.
Nature 341(6242): 516-518, 1989. (GWU 11418)
- Rothschild, L.J. (Des Marais, D.J. = P.I.)
Protozoa, Protista, Protoctista: What's in a name?
Journal of the History of Biology 22(2): 277-305, 1989. (GWU 11432)
- Rothschild, L.J.; Mancinelli*, R.L.
Microbial mats as a model system for the early evolution of carbon metabolism (Abstract).
Origins of Life and Evolution of the Biosphere 19: 413-414, 1989. (GWU 11511)
- Sagan, D.; Margulis*, L. (Eds.)
Biospheres: From Earth to Space. Hillside, NJ: Enslow Publishers, 96 p., 1989. (GWU 11623)
- Schopf*, J.W.
Diversification and extinction in the Proterozoic biosphere (Abstract).
Origins of Life and Evolution of the Biosphere 19: 445-446, 1989. (GWU 11684)
- Sleep, N.H.; Zahnle, K.J.; Kasting*, J.F.; Morowitz, H.J.
Annihilation of ecosystems by large asteroid impacts on the early Earth.
Nature 342(6246): 139-142, 1989. (GWU 11497)
- Stan-Lotter, H.; Hochstein*, L.I.
A comparison of an ATPase from the archaebacterium *Halobacterium saccharovorum* with the F_1 moiety from the *Escherichia coli* ATP synthase.
European Journal of Biochemistry 179: 155-160, 1989. (GWU 11479)
- Stan-Lotter, H.; Lang, F.J., Jr.; Hochstein*, L.I.
Electrophoresis and isoelectric focusing of whole cell and membrane proteins from the extremely halophilic archaebacteria.
Applied and Theoretical Electrophoresis 1: 147-153, 1989. (GWU 11480)
- Swett, K.; Knoll*, A.H.
Marine pisolites from Upper Proterozoic carbonates of East Greenland and Spitsbergen.
Sedimentology 36: 75-93, 1989. (GWU 11503)

- Tindall, B.J.; Tomlinson, G.A.; Hochstein*, L.I.
Transfer of *Halobacterium denitrificans* (Tomlinson, Jahnke, and Hochstein) to the genus *Haloferax* as *Haloferax denitrificans* comb nov.
International Journal of Systematic Bacteriology 39(3): 359-360, 1989. (GWU 11760)
- Trost, J.T.; Blankenship*, R.E.
Isolation of a photoactive photosynthetic reaction center-core antenna complex from *Heliobacillus mobilis*.
Biochemistry 28: 9898-9904, 1989. (GWU 11394)
- Van den Eynde, H.; De Baere, R.; Shah, H.N.; Gharbia, S.E.; Fox*, G.E.; Michalik, J.; Van de Peer, Y.; De Wachter, R.
5S ribosomal ribonucleic acid sequences in *Bacteroides* and *Fusobacterium*: Evolutionary relationships within these genera and among eubacteria in general.
International Journal of Systematic Bacteriology 39(1): 78-84, 1989. (GWU 11449)
- Váró, G.; Lanyi*, J.K.
Photoreactions of bacteriorhodopsin at acid pH.
Biophysical Journal 56(6): 1143-1151, 1989. (GWU 11663)
- Veizer, J.; Hoefs, J.; Lowe*, D.R.; Thurston, P.C.
Geochemistry of Precambrian carbonates: II. Archean greenstone belts and Archean sea water.
Geochimica et Cosmochimica Acta 53: 859-871, 1989. (GWU 10272)
- Veizer, J.; Hoefs, J.; Ridler, R.H.; Jensen, L.S.; Lowe*, D.R.
Geochemistry of Precambrian carbonates: I. Archean hydrothermal systems.
Geochimica et Cosmochimica Acta 53: 845-857, 1989. (GWU 10271)
- Vestal, J.R. (Friedmann, E.I. = P.I.)
The metabolism of the Antarctic cryptoendolithic microbiota (Abstract).
In: *Exobiology and Future Mars Missions* (McKay, C.P., Davis, W.L., Eds.). Moffett Field, CA: NASA, Ames Research Center, p. 59, 1989. (NASA-CP-10027) (GWU 11932)
- Vestal, J.R.; White, D.C. (Friedmann, E.I. = P.I.)
Lipid analysis in microbial ecology: Quantitative approaches to the study of microbial communities.
BioScience 39(8): 535-541, 1989. (GWU 11457)
- Weisburg, W.G.; Giovannoni, S.J.; Woese*, C.R.
The *Deinococcus-Thermus* phylum and the effect of rRNA composition on phylogenetic tree construction.
Systematic and Applied Microbiology 11: 128-134, 1989. (GWU 11314)
- Wisotzkey, J.D.; Jurtshuk, P., Jr.; Fox*, G.E.
Comparative 16S rRNA analysis on thermophilic and psychrophilic *Bacillus* species (Abstract).
In: *Abstracts of the 89th Annual Meeting of the American Society for Microbiology*, New Orleans, LA, May 14-19, 1989, p. 281. (GWU 11455)

Woese*, C.R.

Archaeobacteria and the nature of their evolution.

In: *The Hierarchy of Life: Molecules and Morphology in Phylogenetic Analysis* (Fernholm, B., Bremer, K., Jörnvall, H., Eds.). Amsterdam: Elsevier Science Publishers B.V., p. 119-130, 1989. (GWU 11584)

Woese*, C.R.; Gutell, R.R.

Evidence for several higher order structural elements in ribosomal RNA.

Proceedings of the National Academy of Sciences, USA 86: 3119-3122, 1989. (GWU 10304)

Zimányi, L.; Keszthelyi, L.; Lanyi*, J.K.

Transient spectroscopy of bacterial rhodopsins with an optical multichannel analyzer.

1. Comparison of the photocycles of bacteriorhodopsin and halorhodopsin.

Biochemistry 28(12): 5165-5172, 1989. (GWU 11662)

Zimányi, L.; Lanyi*, J.K.

Halorhodopsin: A light-driven active chloride transport system.

Annals of the New York Academy of Sciences 574: 11-19, 1989. (GWU 11667)

Zimányi, L.; Lanyi*, J.K.

Low-temperature photoreactions of halorhodopsin. 2. Description of the photocycle and its intermediates.

Biochemistry 28(4): 1662-1666, 1989. (GWU 11659)

Zimányi, L.; Lanyi*, J.K.

Transient spectroscopy of bacterial rhodopsins with an optical multichannel analyzer. 2. Effects of anions on the halorhodopsin photocycle.

Biochemistry 28(12): 5172-5178, 1989. (GWU 11661)

Zimányi, L.; Ormos, P.; Lanyi*, J.K.

Low-temperature photoreactions of halorhodopsin. 1. Detection of conformational substates of the chromoprotein.

Biochemistry 28(4): 1656-1661, 1989. (GWU 11660)

EVOLUTION OF ADVANCED LIFE

Billingham*, J.

The evolution of complex life.

Acta Astronautica 19(11): 863-868, 1989. (GWU 11988)

Briggs*, J.C.

The historic biogeography of India: Isolation or contact?

Systematic Zoology 38(4): 322-332, 1989. (GWU 11274)

Jablonski, D. (Raup, D.M. = P.I.)

The biology of mass extinction: A palaeontological view.

Philosophical Transactions of the Royal Society of London B 325: 357-368, 1989. (GWU 11561)

Raup*, D.M.

The case for extraterrestrial causes of extinction.

Philosophical Transactions of the Royal Society of London B 325: 421-435, 1989. (GWU 11666)

Roughgarden*, J.

The structure and assembly of communities.

In: *Perspectives in Ecological Theory* (Roughgarden, J., May, R.M., Levin, S.A., Eds.).

Princeton, NJ: Princeton University Press, p. 203-226, 1989. (GWU 10661)

Roughgarden*, J.; May, R.M.; Levin, S.A. (Eds.)

Perspectives in Ecological Theory. Princeton, NJ: Princeton University Press, 394 p., 1989. (GWU 8950)

Sepkoski*, J.J., Jr.

Extinction events in the fossil record: An overview (Abstract).

Geological Society of America, Abstracts with Program 21(4): A47, 1989. (GWU 11571)

Sepkoski*, J.J., Jr.

The importance of extinction resistance in onshore-offshore changes in faunal dominance during evolutionary radiations (Abstract).

Geological Society of America, Abstracts with Program 21(6): A30, 1989. (GWU 11572)

Sepkoski*, J.J., Jr.

Periodicity in extinction and the problem of catastrophism in the history of life.

Journal of the Geological Society, London 146: 7-19, 1989. (GWU 11569)

Valentine, J.W.; Tiffney, B.H.; Sepkoski*, J.J., Jr.

The evolutionary dynamics of plants and animals: A comparative approach (Abstract).

Geological Society of America, Abstracts with Program 21(6): A146, 1989. (GWU 11573)

SOLAR SYSTEM EXPLORATION

- Becker, J.F.; Yaldae, R.; McKay*, C.P.
Stable isotope laser spectroscopy (Abstract).
In: *Exobiology and Future Mars Missions* (McKay, C.P., Davis, W.L., Eds.) Moffett Field, CA: NASA, Ames Research Center, p. 9, 1989. (NASA-CP-10027) (GWU 11926)
- Belton, M.; Betz*, A.; Black, J.; Cohen, M.; Encrenaz, T.; Evans, N.; Feldman, P.D.; Herbst, E.; Kerridge*, J.; McKay*, C.; Nuth, J.; Roellig, T.; Scattergood*, T.; Tarter*, J.; Tielens, A.; Veverka, J.
Observational exobiology.
In: *Exobiology in Earth Orbit* (DeFrees, D., Brownlee, D., Tarter, J., Usher, D., Irvine, W., Klein, H., Eds.). Moffett Field, CA: NASA, Ames Research Center, p. 19-75, 1989. (NASA-SP-500) (GWU 11604)
- Benz, W.; Cameron, A.G.W.; Melosh*, H.J.
The origin of the Moon and the single-impact hypothesis III.
Icarus 81: 113-131, 1989. (GWU 11319)
- Berry, W.; Duke, M.; Tarter*, J.
Observational and experimental opportunities in Earth orbit.
In: *Exobiology in Earth Orbit* (DeFrees, D., Brownlee, D., Tarter, J., Usher, D., Irvine, W., Klein, H., Eds.). Moffett Field, CA: NASA, Ames Research Center, p. 7-17, 1989. (NASA-SP-500) (GWU 11601)
- Chyba, C.F.; Squyres, S.W.; Sagan*, C.
Depth to unoxidized material in the Martian regolith (Abstract).
Lunar and Planetary Science Conference XX: 157-158, 1989. (GWU 11606)
- de Bergh, C.; Lutz, B.L.; Owen*, T.; Maillard, J.-P.
Measurements of the D/H ratio in planetary atmospheres by ground based infrared spectroscopy.
In: *Infrared Spectroscopy in Astronomy* (Kaldeich, B.H., Ed.). Paris: European Space Agency, p. 41-47, 1989. (ESA-SP-290) (GWU 11544)
- DeVincenzi*, D.L.
Life in the universe: Space exploration opportunities (Abstract).
Origins of Life and Evolution of the Biosphere 19: 488, 1989. (GWU 11753)
- Fogleman, G.; Huntington, J.L.; Carle*, G.C.
Collection of cosmic dust in Earth orbit for exobiological analysis (Abstract).
Origins of Life and Evolution of the Biosphere 19: 465-466, 1989. (GWU 11685)
- Fogleman, G.; Huntington, J.L.; Carle*, G.C.; Nuth, J.A.
Microgravity particle research on the Space Station: The Gas-Grain Simulation Facility.
Advances in Space Research 9(2): 91-94, 1989. (GWU 11397)
- Fogleman, G.; Huntington, J.L.; Schwartz, D.E.; Fonda, M.L. (Eds.)
Gas-Grain Simulation Facility: Fundamental Studies of Particle Formation and Interactions. Volume 1: Executive Summary and Overview. Moffett Field, CA: NASA, Ames Research Center, 36 p., 1989. (NASA-CP-10026) (GWU 11703)

Fogleman, G.; Huntington, J.L.; Schwartz, D.E.; Fonda, M.L. (Eds.)
Gas-Grain Simulation Facility: Fundamental Studies of Particle Formation and Interactions. Volume 2: Abstracts, Candidate Experiments, And Feasibility Study. Moffett Field, CA: NASA, Ames Research Center, 201 p., 1989. (NASA-CP-10026) (GWU 11704)

Gautier, D.; Owen*, T.
The composition of outer planet atmospheres.
In: *Origin and Evolution of Planetary Satellite Atmospheres* (Atreya, S.K., Pollack, J.B., Matthews, M., Eds.). Tucson, AZ: University of Arizona Press, p. 487-512, 1989. (GWU 11321)

Gehrke, C.W.; Ponnampertuma*, C.; Kuo, K.C.; Stalling, D.L.; Zumwalt, R.W.
The search for and identification of amino acids, nucleobases and nucleosides in samples returned from Mars (Abstract).
In: *Exobiology and Future Mars Missions* (McKay, C.P., Davis, W.L., Eds.) Moffett Field, CA: NASA, Ames Research Center, p. 23-24, 1989. (NASA-CP-10027) (GWU 11938)

Gehrke, C.W.; Ponnampertuma*, C.; Zumwalt, R.; Stalling, D.
The role of a lunar-based chemical biology/medical analysis laboratory (LBCAL) on the moon.
In: *Ninth College Park Colloquium on Chemical Evolution*, College Park, MD, October 29-31, 1989, p. 7-9. (GWU 11551)

Gibson*, E.K., Jr.
Analytical requirements of a lunar base.
Paper presented at the Lunar-Based Chemical Analysis Laboratory Colloquium, University of Maryland, College Park, MD, October 30-31, 1989.

Gibson*, E.K., Jr.
Soil development in polar deserts: Implications for Exobiology and future Mars missions (Abstract).
In: *Exobiology and Future Mars Missions* (McKay, C.P., Davis, W.L., Eds.) Moffett Field, CA: NASA, Ames Research Center, p. 25, 1989. (NASA-CP-10027) (GWU 11937)

Gooding, J.L. (McKay, C.P. = P.I.)
Mineralogical sinks for biogenic elements on Mars (Abstract).
In: *Exobiology and Future Mars Missions* (McKay, C.P., Davis, W.L., Eds.) Moffett Field, CA: NASA, Ames Research Center, p. 27, 1989. (NASA-CP-10027) (GWU 11936)

Gooding, J.L.; Carr, M.H.; McKay*, C.P.
The case for planetary sample return missions. 2. History of Mars.
Eos 70(31): 745-750, 1989. (GWU 11517)

Houdashelt, M.L.; Bustin, R.; Gibson*, E.K.
Hydrogen extraction from lunar soil: Methods applicable to a lunar processing facility (Abstract).
Lunar and Planetary Science Conference XX: 424-425, 1989. (GWU 11628)

Huntington, J.L.; Fogleman, G. (Carle, G.C. = P.I.)
On performing exobiology experiments on an Earth-orbital platform with the gas-grain simulation facility (Abstract).
Origins of Life and Evolution of the Biosphere 19: 493-494, 1989. (GWU 11641)

Irvine*, W.M.; Lumme, K.; Zhukov, B.S.

Disk-integrated photometry of Phobos from the Phobos 2 spacecraft.

Bulletin of the American Astronomical Society 21: 989, 1989.

Kanavarioti*, A.; Mancinelli*, R.L.

Chemical evolution and the preservation of organic compounds on Mars (Abstract).

In: *Exobiology and Future Mars Missions* (McKay, C.P., Davis, W.L., Eds.) Moffett Field, CA: NASA, Ames Research Center, p. 34-35, 1989. (NASA-CP-10027) (GWU 11935)

Klein*, H.P.

The Viking Biology results (Abstract).

In: *Exobiology and Future Mars Missions* (McKay, C.P., Davis, W.L., Eds.) Moffett Field, CA: NASA, Ames Research Center, p. 36-37, 1989. (NASA-CP-10027) (GWU 11933)

Klingler, J.M.; Mancinelli*, R.L.; White, M.R.

Biological nitrogen fixation under primordial Martian partial pressures of dinitrogen.

Advances in Space Research 9(6): 173-176, 1989. (GWU 11514)

Klingler, J.M.; Mancinelli*, R.L.; White, M.R.

Ecological considerations for possible Martian biota (Abstract).

In: *Exobiology and Future Mars Missions* (McKay, C.P., Davis, W.L., Eds.). Moffett Field, CA: NASA, Ames Research Center, p. 38, 1989. (NASA-CP-10027) (GWU 10278)

Levine*, J.S.

Venus' atmosphere.

In: *Magill's Survey of Science: Space Exploration Series*, Volume 5 (Magill, F.N., Ed.). Englewood Cliffs, NJ: Salem Press, p. 2132-2137, 1989. (GWU 11634)

Levine*, J.S.; McKay*, C.P.

A search for biogenic trace gases in the atmosphere of Mars (Abstract).

In: *Exobiology and Future Mars Missions* (McKay, C.P., Davis, W.L., Eds.) Moffett Field, CA: NASA, Ames Research Center, p. 39, 1989. (NASA-CP-10027) (GWU 11934)

Levine*, J.S.; Rinsland, C.P.; Charmeides, W.L.; Boston, P.J.; Cofer, W.R., III; Brimblecombe, P.

Trace gases in the atmosphere of Mars: An indicator of microbial life.

In: *The Case for Mars III: Strategies for Exploration - Technical* (Stoker, C.R., Ed.). San Diego, CA: American Astronomical Society, p. 277-282, 1989. (GWU 11630)

Mancinelli*, R.L.

The nitrogen cycle on Mars (Abstract).

In: *Exobiology and Future Mars Missions* (McKay, C.P., Davis, W.L., Eds.) Moffett Field, CA: NASA, Ames Research Center, p. 42, 1989. (NASA-CP-10027) (GWU 11931)

Mancinelli*, R.L.

Peroxides and the survivability of microorganisms on the surface of Mars.

Advances in Space Research 9(6): 191-195, 1989. (GWU 11515)

McKay*, C.P.; Borucki, W.R.; Kojiro*, D.R.; Church, F.

Shock production of organics during cometary impact (Abstract).

Lunar and Planetary Science Conference XX: 671-672, 1989. (GWU 11614)

- McKay*, C.P.; Davis, W.L.
Exobiology and Future Mars Missions. Moffett Field, CA: NASA, Ames Research Center, 72 p., 1989. (NASA-CP-10027) (GWU 9856)
- McKay*, C.P.; Pollack, J.B.; Courtin, R.
 The thermal structure of Titan's atmosphere.
Icarus 80: 23-53, 1989. (GWU 11522)
- McKay*, C.P.; Stoker, C.R.
 The early environment and its evolution on Mars: Implications for life.
Reviews of Geophysics 27: 189-214, 1989. (GWU 11520)
- Melosh*, H.J.; Kipp, M.E.
 Giant impact theory of the moon's origin: First 3-D hydrocode results (Abstract).
Lunar and Planetary Science Conference XX: 685-686, 1989. (GWU 11613)
- Melosh*, H.J.; Vickery, A.M.
 Impact erosion of the primordial atmosphere of Mars.
Nature 338(6215): 487-489, 1989. (GWU 11524)
- Meyer, T.R.; McKay*, C.P.
 The resources of Mars for human settlement.
Journal of the British Interplanetary Society 42: 147-160, 1989. (GWU 11523)
- Moses*, J.I.; Allen, M.; Yung*, Y.L.
 Neptune's visual albedo variations over a solar cycle: A pre-Voyager look at ion-induced nucleation and cloud formation in Neptune's troposphere.
Geophysical Research Letters 16: 1489-1492, 1989.
- Nedell, S.S.; McKay*, C.P.
 Are there carbonate deposits in the Valles Marineris, Mars? (Abstract)
 In: *Exobiology and Future Mars Missions* (McKay, C.P., Davis, W.L., Eds.) Moffett Field, CA: NASA, Ames Research Center, p. 44-45, 1989. (NASA-CP-10027) (GWU 11930)
- Oberbeck, V.R. (Carle, G.C. = P.I.)
 Sampling stratospheric aerosols with impactors.
Aerosol Science and Technology 11: 65-79, 1989. (GWU 11430)
- Oberbeck, V.R.; Fogleman, G. (Carle, G.C. = P.I.)
 On the possibility of life on early Mars (Abstract).
Lunar and Planetary Science Conference XX: 800-801, 1989. (GWU 12000)
- Oberbeck, V.R.; Livingston, J.M.; Russell, P.B.; Pueschel, R.F.; Rosen, J.N.; Osborn, M.T.; Kritz, M.A.; Snetsinger, K.G.; Ferry, G.V. (Carle, G.C. = P.I.)
 SAGE II aerosol validation: Selected altitude measurements, including particle micrometeorite measurements.
Journal of Geophysical Research 94(D6): 8367-8380, 1989. (GWU 11657)
- Oberbeck, V.R.; O'Hara, D.; Carle*, G.C.
 Concepts for collection of aerosols in Titan's atmosphere.
Journal of Geophysical Research 92(B4): E717-E722, 1989. (GWU 11564)

- Oró*, J.; Mills, T.
Sulfur metabolism: An anaerobic strategy for microbial life on Europa (Abstract).
Origins of Life and Evolution of the Biosphere 19: 479-480, 1989. (GWU 8119)
- Owen*, T.; Gautier, D.
Titan: Some new results.
Advances in Space Research 9(2): 73-78, 1989. (GWU 11546)
- Rothschild, L.J.; Des Marais*, D.
Stable carbon isotope fractionation in the search for life on early Mars.
Advances in Space Research 9(6): 159-165, 1989. (GWU 11421)
- Scattergood*, T.; Oberbeck, V.; McKay*, C.; Borucki, J.; O'Hara, B.; Valentin*, J.; Kojiro, D.; Snetsinger, K.; Verma, S.; Carle*, G.
The study of Titan from an exobiological perspective.
Origins of Life and Evolution of the Biosphere 19: 473-474, 1989. (GWU 11751)
- Schwartz, D.E.; Mancinelli*, R.L.
Bio-markers and the search for extinct life on Mars.
Advances in Space Research 9(6): 155-158, 1989. (GWU 11513)
- Schwartz, D.E.; Mancinelli*, R.L.; Marshall, J.
Crystal properties as bio-markers: A potential MRSR experiment (Abstract).
Origins of Life and Evolution of the Biosphere 19: 501-502, 1989. (GWU 11512)
- Schwartz, D.E.; Mancinelli*, R.L.; O'Hara, B.J.
Viking and Mars Rover exobiology (Abstract).
In: *Exobiology and Future Mars Missions* (McKay, C.P., Davis, W.L., Eds.) Moffett Field, CA: NASA, Ames Research Center, p. 54, 1989. (NASA-CP-10027) (GWU 11929)
- Simonelli, D.P.; Pollack, J.B.; McKay*, C.P.; Reynolds, R.T.; Summers, A.L.
The carbon budget in the outer solar nebula.
Icarus 82: 1-35, 1989. (GWU 11519)
- Sims, M.H.; Fischler, M.; Schwartz, D.E.; Rosenthal, D.A.; Mancinelli*, R.L.; Nedell, S.S.; Gamble, E.; McKay*, C.P.
Mars Rover Sample Return: A sample collection and analysis strategy for exobiology (Abstract).
In: *Exobiology and Future Mars Missions* (McKay, C.P., Davis, W.L., Eds.) Moffett Field, CA: NASA, Ames Research Center, p. 55, 1989. (NASA-CP-10027) (GWU 11928)
- Thompson, W.R.; Henry, T.; Schwartz, J.; Khare*, B.N.; Sagan*, C.
Production and fate of hydrocarbons, nitriles, and heteropolymers on Titan (Abstract).
Origins of Life and Evolution of the Biosphere 19: 475-476, 1989. (GWU 11758)
- Thompson, W.R.; Sagan*, C.
Photometric properties and classification of small jovian cloud features.
In: *Time-Variable Phenomena in the Jovian System* (Belton, M.J.S., West, R.A., Rahe, J., Eds.). Washington, DC: NASA Headquarters, p. 297-305, 1989. (NASA-SP-494) (GWU 11594)
- Thompson, W.R.; Singh, S.K.; Khare*, B.N.; Sagan*, C.
Triton: Stratospheric molecules and organic sediments.
Geophysical Research Letters 16: 981-984, 1989.

- Tsou*, P.; Aubert, J.; Brownlee, D.; Hrubesh, L.; Williams, J.; Albee, A.
Effectiveness of intact capture media (Abstract).
Lunar and Planetary Science Conference XX: 1132-1133, 1989. (GWU 11611)
- Tsou*, P.; Bradley, J.G.; Brownlee, D.E.; Albee, A.L.
Nondestructive cosmic dust positioning and velocity sensor (Abstract).
Lunar and Planetary Science Conference XX: 1134-1135, 1989. (GWU 11610)
- Valentin*, J.R.
Multiplex gas chromatography: An alternative concept for gas chromatographic analysis of planetary atmospheres.
LC-GC 7(3): 248-254, 1989. (GWU 11576)
- Valentin*, J.R.; Hall, K.W.
Mechanical modulation for multiplex gas chromatographic analyses at subatmospheric pressures.
Journal of High Resolution Chromatography 12: 53-55, 1989. (GWU 11575)
- Vickery, A.M.; Melosh*, H.J.
Atmospheric erosion by impacts: Evidence for an early, dense atmosphere on Mars (Abstract).
Eos 70: 1172, 1989. (GWU 11526)
- Wang, P.-H.; McCormick, M.P.; McMaster, L.R.; Shu, W.P.; Swissler, T.J.; Osborn, M.T.; Russell, P.B.; Oberbeck, V.R.; Livingston, J.; Rosen, J.M.; Hofmann, D.J.; Grams, G.W.; Fuller, W.H.; Yue, G.K. (Carle, G.C. = P.I.)
SAGE II aerosol data validation based on retrieved aerosol model size distribution from SAGE II aerosol measurements.
Journal of Geophysical Research 94(D6): 8381-8393, 1989. (GWU 11759)
- Wharton*, R.A., Jr.; McKay*, C.P.; Mancinelli*, R.L.; Clow, G.D.; Simmons, G.M., Jr.
The Antarctic Dry Valley Lakes: Relevance to Mars (Abstract).
In: *Exobiology and Future Mars Missions* (McKay, C.P., Davis, W.L., Eds.) Moffett Field, CA: NASA, Ames Research Center, p. 62, 1989. (NASA-CP-10027) (GWU 11927)
- Wharton*, R.A., Jr.; McKay*, C.P.; Mancinelli*, R.L.; Simmons, G.M., Jr.
Early Martian environments: The Antarctic and other terrestrial analogs.
Advances in Space Research 9(6): 147-153, 1989. (GWU 11581)
- Wharton*, R.A., Jr.; Simmons, G.M., Jr.; McKay*, C.P.
Perennially ice-covered Lake Hoare, Antarctica: Physical environment, biology and sedimentation.
Hydrobiologia 172: 305-320, 1989. (GWU 10136)
- Zent, A.P.; McKay*, C.P.; Pollack, J.B.; Cruikshank, D.P.
Grain metamorphism in polar nitrogen ice on Triton.
Geophysical Research Letters 16: 965-968, 1989.

SEARCH FOR EXTRATERRESTRIAL INTELLIGENCE (SETI)

- Betz*, A.L.; Boreiko, R.T.
Reversed far-infrared line emission from OH in Orion.
Astrophysical Journal (Letters) 346: L101-L104, 1989. (GWU 11668)
- Billingham*, J.; Tarter*, J.
Detection of the Earth with the SETI microwave observing system assumed to be operating out in the galaxy.
Paper presented at the 40th Congress of the International Astronautical Federation, Malaga, Spain, October 7-12, 1989, 8 p. (IAF Paper 89-647) (GWU 11574)
- Boreiko, R.T.; Betz*, A.L.
Heterodyne spectroscopy of the $J = 22-21$ CO line in Orion.
Astrophysical Journal (Letters) 346: L97-L100, 1989. (GWU 11641)
- Boreiko, R.T.; Betz*, A.L.; Zmuidzinas, J.
Heterodyne spectroscopy of the $J = 17-16$ CO line in Orion.
Astrophysical Journal 337: 332-341, 1989. (GWU 11324)
- Duluk, J.F.; Linscott, I.R.; Peterson*, A.M.; Burr, J.; Ekroot, B.; Twicken, J.
VLSI processors for signal detection in SETI.
Acta Astronautica 19(11): 927-932, 1989. (GWU 11989)
- Gulkis*, S.
Analysis of a crossed bragg cell acousto-optical spectrometer for SETI.
Acta Astronautica 19(11): 919-925, 1989. (GWU 11436)
- Gulkis*, S.; Klein*, M.J.; Olsen, E.T.; Garyantes, M.F.; Wilck, H.C.; Deich, W.T.S.; Brady, R.B.; Burns, D.J.
Status of the NASA SETI Sky Survey Observing Project.
Paper presented at the 40th Congress of the International Astronautical Federation, Malaga, Spain, October 7-13, 1989, 12 p. (IAF Paper 89-641) (GWU 11437)
- Heidmann, J.; Biraud, F.; Tarter*, J.
Pulsar-aided SETI experimental observations.
Paper presented at the 40th Congress of the International Astronautical Federation, Malaga, Spain, October 7-13, 1989, 7 p. (IAF Paper 89-642) (GWU 11631)
- Klein*, M.J.; Brin, G.D.
CETI.
In: *Encyclopedia of Communications* (Barnouw, E., Ed.). New York: Oxford University Press, p. 252-255, 1989. (GWU 11665)
- Klein*, M.J.; Gulkis*, S.; Olsen, E.T.; Renzetti, N.A.
The NASA SETI Sky Survey: Recent developments.
In: *JPL-TDA Progress Report 42-98*. Pasadena, CA: NASA, Jet Propulsion Laboratory, p. 218-226, 1989. (GWU 11438)
- Kuiper, T.B.H.; Brin, G.D. (Klein, M.J. = P.I.)
Resource letter ETC-1: Extraterrestrial civilization.
American Journal of Physics 57(1): 12-18, 1989. (GWU 11440)

Miller, A.; Jelinsky, P.; Bowyer*, S.; Welsh, B.Y.
Small blaze angle gratings with various surface treatments for use in the extreme ultraviolet.
Applied Optics 28: 4971-4973, 1989. (GWU 11621)

Seeger, C.L.; Martin, A.R. (Eds.)
SETI: The search for extraterrestrial intelligence.
Acta Astronautica 19(11): 87 p., 1989. (GWU 11990)

Tarter*, J.
Bridges from new worlds.
In: *Space Technology International 1989* (Turnill, R., Ed.). London: Cornhill Publications Ltd,
p. 258-259, 1989. (GWU 11991)

Tarter*, J.
Radio frequency interference at Jodrell Bank Observatory within the protected 21 cm band.
Acta Astronautica 19(11): 907-912, 1989. (GWU 11992)

Tarter*, J.
SETI: The farthest frontier.
In: *Frontiers of Science* (Scott, A., Ed.). Oxford, England: Basil Blackwell Ltd, 14 p., 1989.
(GWU 11993)

Zmuidzinas, J.; Betz*, A.L.; Boreiko, R.T.
A corner-reflector mixer mount for far infrared wavelengths.
Infrared Physics 29: 119-131, 1989. (GWU 10753)

PLANETARY PROTECTION

DeVincenzi*, D.L.

Proposed planetary protection guidelines for sample return missions (Abstract).

Origins of Life and Evolution of the Biosphere 19: 485, 1989. (GWU 11752)

DeVincenzi*, D.L.; Klein*, H.P.

Planetary protection issues for sample return missions.

Advances in Space Research 9(6): 203-206, 1989. (GWU 11425)

McKay*, C.P.; Davis, W.L.

Planetary protection issues in advance of human exploration of Mars.

Advances in Space Research 9(6): 197-202, 1989. (GWU 11521)

Rummel*, J.D.

Planetary protection policy overview and application to future missions.

Advances in Space Research 9(6): 181-184, 1989. (GWU 11995)

GENERAL

DeFrees*, D.; Brownlee, D.; Tarter*, J.; Usher*, D.; Irvine*, W.; Klein*, H. (Eds.)
Exobiology in Earth Orbit. Moffett Field, CA: NASA, Ames Research Center, 126 p., 1989.
(NASA-SP-500) (GWU 11603)

Klein*, H.P.

Biology and the space sciences.

In: *Exobiology in Earth Orbit* (DeFrees, D., Brownlee, D., Tarter, J., Usher, D., Irvine, W., Klein, H., Eds.). Moffett Field, CA: NASA, Ames Research Center, p. 1-5, 1989.
(NASA-SP-500) (GWU 11600)

Oró*, J. (Ed.)

Life Sciences and Space Research XXIII (1): Exobiology Science and Primitive Solar System Bodies.

Advances in Space Research 9(2): 121 p., 1989. (GWU 11542)

Schwartz, A.W.; Dose, K.; Raup*, D.M.; Klein*, H.P.; DeVincenzi*, D.L. (Eds.)

Life Sciences and Space Research XXIII (2): Planetary Biology and Origins of Life.

Advances in Space Research 9(6): 219 p., 1989. (GWU 11560)

ADDENDUM

These publications were inadvertently omitted from the 1988 Bibliography.

Bonani, G.; Friedmann*, E.I.; Ocampo-Friedmann, R.; McKay*, C.P.; Woelfli, W.
Preliminary report on radiocarbon dating of cryptoendolithic microorganisms.
Polarforschung 58(2/3): 199-200, 1988. (GWU 11460)

Friedmann*, E.I.; Hua, M.; Ocampo-Friedmann, R.
Cryptoendolithic lichen and cyanobacterial communities of the Ross Desert, Antarctica.
Polarforschung 58(2/3): 251-259, 1988. (GWU 11462)

Kite, G.C.; Rothschild, L.J.; Dodge, J.D. (Mancinelli, R.L. = P.I.)
Nuclear and plastid DNAs from the binucleate dinoflagellates *Glenodinium* (*Peridinium*)
foliaceum and *Peridinium balticum*.
BioSystems 21: 151-163, 1988. (GWU 8122)

Koch, W.; Lui, B.; DeFrees*, D.J.
The $C_4H_7^+$ cation: A theoretical investigation.
Journal of the American Chemical Society 110: 7325-7328, 1988. (GWU 11643)

Mancinelli*, R.; McKay*, C.P.
The evolution of nitrogen cycling.
Origins of Life and Evolution of the Biosphere 18: 311-325, 1988. (GWU 11516)

Meyer, M.A.; Huang, G.-H.; Morris, G.J.; Friedmann*, E.I.
The effect of low temperatures on Antarctic endolithic green algae.
Polarforschung 58(2/3): 113-119, 1988. (GWU 11463)

Ocampo-Friedmann, R.; Meyer, M.A.; Chen, M.; Friedmann*, E.I.
Temperature response of Antarctic cryptoendolithic photosynthetic microorganisms.
Polarforschung 58(2/3): 121-124, 1988. (GWU 11464)

Osawa, S.; Jukes*, T.H.
Evolution of the genetic code as affected by anticodon content.
Trends in Genetics 4(7): 191-198, 1988. (GWU 11487)

Palma, A.; Green, S.; DeFrees*, D.J.; McLean, A.D.
Collisional excitation of interstellar water.
Astrophysical Journal Supplement Series 68: 287-318, 1988. (GWU 11322)

Palmer, R.J., Jr.; Friedmann*, E.I.
Incorporation of inorganic carbon by Antarctic cryptoendolithic fungi.
Polarforschung 58(2/3): 189-191, 1988. (GWU 11465)

Rothschild, L.J.; Heywood, P. (Mancinelli, R.L. = P.I.)
"Protistan" nomenclature: Analysis and refutation of some potential objections.
BioSystems 21: 197-202, 1988.

Vestal, J.R. (Friedmann, E.I. = P.I.)
Primary production of cryptoendolithic microbiota for the Antarctic Desert.
Polarforschung 58(2/3): 193-198, 1988. (GWU 11459)

Yung*, Y.L.; Drew, W.A.; Pinto, J.P.; Friedl, R.R.
Estimation of the reaction rate for the formation of CH_3O from $\text{H} + \text{H}_2\text{CO}$: Implications for chemistry in the solar system.
Icarus 73: 516-526, 1988. (GWU 11588)

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